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Vol. 4. No. 1 Pittsburgh, Pa. January, 1931

IN THIS ISSUE

Editorial

◆

Handbook of Laboratory Instruments and Apparatus
ARTHUR SCHRODER

◆

Handbook of Industrial Instruments
M. F. BÉHAR

◆

New Instruments:

"Opacus" Metal Microscope
Relays for Use with Light Sensitive Cells
Photoelectric Relay
New Push Button Master Station
New CO_2 Indicator and Recorder
New Mirror Extensometer
Thread Snap Gage
New Pressure Gage
New Time Switch
Steel Spring Recording Gages
Wood Moisture Balance
Bailey Meters and Control
Universal Two-Co-ordinate Measuring Machine
Work-Cycle Time
Ultra-Violet Radiation Indicator
New Electric Gage
New Improved Tubular Rheostat
New Exhaust Gas Analyzing Device
Slide Wire Model Control Transformer

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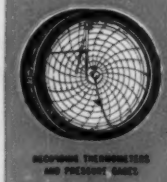

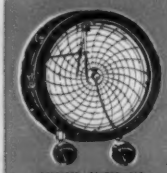

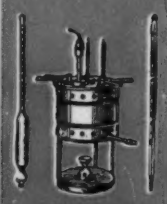

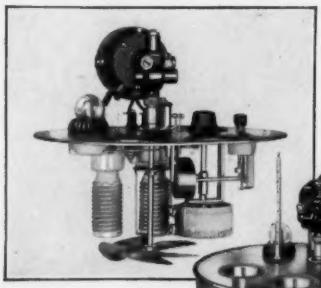

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SUBJECT INDEX

A-C Instruments 620
Acceleration Measurement 649
Acoustimeter 197
Air-Butane Ratio Controller 109
Aircraft Indicating Instruments 129
Air Operated Recorder Controller 563
Altimeter, Sonic 118
Anemometers 182, 445
Anti-Ambi Thermometer 697
Astronomical Observer's Platform 130
Auto Gage, Aggregate 132
Auto-Gage, Ice Cream Over-Run 364
Auto-Gage, Piston Ring and Valve Spring. 364
Automatic Recording Revolution Counter. 251
Automatic Temperature and Safety Control 128
Automatic Timers, Special Duty 641
Balances, Analytical 3
Balances, Assay 87
Balances, Bates Sugar 87
Balances, Board 87
Balances, Bullion 87
Balances, Centrifuge Tube 87
Balances, Chainomatic 3, 87
Balances, Chemical 3
Balances, Cordage 87
Balances, Counting 87
Balances, Differential 87
Balances, Dispensing 87
Balances, Drug 87
Balances, Foil 87
Balances, Gas Density 87
Balances, Geological Torsion 87
Balances, Gold Coin 87
Balances, Gravitometer 87
Balances, Hand 87
Balances, Jewelers' 87
Balances, Jolly 87
Balances, Magnetic Susceptibility 87
Balances, Metric Solution 87
Balances, Micro Analytical 3
Balances, Multiple Beam 87
Balances, Paper 87
Balances, Paper Basis Weight 87
Balances, Pearl 87
Balances, Percentage Weight 87
Balances, Prescription 87
Balances, Pulp 87
Balances, Quadrant 87
Balances, Scales and Weights 87
Balances, Silk Skein 87
Balances, Robervahl 87
Balances, Silver 87
Balances, Solder Test 87
Balances, Specie 87
Balances, Specific Gravity 87
Balances, Surface Tension Over and Under 87
Balances, Torsion 3
Balances, Wood Moisture 87
Balancing Machine Dynamic 629
Balloon Theodolite Recording 135
Barometers, Aneroid 143
Bend Machine, Reverse 704
Bending Machine for Static and Repeated Reversed Loads, Foeppl-Heydekampf ... 133
Blue-Printing Equipment 626
Brake Featured on New Wire Meter 461
Brake Meter, Tapley Safety 198
Brinell Hardness Tester, Wazau 249
Bursting Strength Tester, Shopper Dalen. 397
Calorimeter, Adiabatic 512
Carbon Dioxide Indicator and Recorder .. 31
Cathode-Ray Oscilloscope 573
Cathode-Ray Tube, Small Portable 635
Centralized Control Improved Production. 51
Chlorine Comparators 568
Chronographs 320, 647
Color Analyzer, Recording 211
Comparator for Checking Steel Balls, Special 514
Compensated Tubing, Tycos 248
Constancy Test for Photo Tubes 292
Control Valves 124
Controller, Printing Press 296
Controller, Saturation 198
Controllers, Combination 346
Controllers, Condition Time Curve 342
Controllers, Program 328
Controllers, Time 323
Controls for Adjusting Rolls in Steel Mills. 131
Corrosion Tester for Pressure Vessels 527
Counter, Predetermining 247
Counters, Revolution and Stroke 413
Counting and Estimating Scales 260
Cycle Controllers, Pneumatic 336, 398
Cylinder Test Gage 248
Damping Tester, Foeppl-Pertz 111
Demand Meter 259
Draft Gage, Straight-Line Movement 457
Ductility Testing Machine 630
Duragauge 259
Dynamometer Auto Gage 121
Electric Eye May Protect Orchards 634
Electric Eye Sees Paper Break and Stops Printing Press 294
Electric Gage 45
Electrolimit Gage 507
Electrometer, Compton 110
Electrosounder 643
Electro-Viscometer 258
Excess Temperature Cutout 136
Extensometer, Mirror 32
Flow Control, Water 694
Flow Instruments, New 561
Flow Meters, Recording, Integrating and Indicating 408
Fuel-and-Air Ratio Meter 516
Gage for Large Holes 396
Gage, Ionization 241
Gage, McLeod 233
Gage Protector 567
Gage Testers, Dead Weight 20, 57
Gage Testers, Liquid Column 19
Gages, Bellows 150
Gages, Bourdon 143
Gages, Diaphragm 150
Gas Analyzing Device, Exhaust 47
Gas Analyzer, Portable 625
Gas Leak Indicator 700
Graphic Instruments, Flush Type 565
Gyro, Directional 462
Handbook of Industrial Instruments 17
Handbook of Laboratory Instruments and Apparatus 3
Hardness Tester 628, 692
High-Voltage Testing Set, Universal 295
Hydraulic Universal Tester 357
Hydrogen Ion Slide Comparator 126
Hydrometer, Continuous Blow-Off 401
Impact Strain Gage 265
Indicator Speeds Packing 463
Indicator With Free-Rotating Drum for Taking Time Diagrams 291
Indicator With Initial-Tension 292
Indicators, Elapsed Time 309
Industrial Thermometer, Snap Case-Front 287
Inspection Gage, Rapid 458
Instrument Hairsprings 532
Instrument Measures and Controls Heating Effect of Gases 205
Instrument Pivots 105
Instrument Protection With Fuses 115
Instrument Springs and Diaphragms 173
Integrator, EMCO-McGaughy 638
Julius Suspensions 277
Laboratory Scale 511
Lathe Precision Threading 137
Level Oil Control for Machine Bearings .. 250
Light Capacity Direct Reading Scale 506
Light-Sensitive Cell 464
Light Sensitive Unit 637
Lubricant Tester 253
Machine That Throws Out Bad Beans 469
Machine Used to Classify Lighting Company Bills 622
Magnetic Measurements 475
Magnifier, Wide Field 522
Manometers 533
Manometers, Contact 65
Manometers, Industrial 55
Manometers, Inverted Bell 81
Manometers, Pendulum 59

E. Eng. Lib.

Manometers, Single Tube 68
Manometers, U-tube 64
Measurement, Air Flow 182, 445, 480, 533
Measurement of Velocity and Director of Water Currents 576
Measuring Bridge, "Z" Type 633
Measuring Machine, Universal Two-Coordinate 41
Megohmer, 1000-Volt 199
Melting Point Apparatus, Dennis 509
Mercury Thermometer Tubing, Black Back 196
Metallographic Polishing Machine 122, 123
Metallus 404
Meters, Frequency 549
Method of Pivoting on Instruments 105
Micro-Indicator Stand, Société Genevoise 359
Micromanometers 73
Microscope, Binocular Research 262
Microscopes, Measuring 360
Microscope Measuring Instrument, Special Double Micrometer 507
Microscope, Micrometer 465
Microscope, New 350 Power 127
Microscope, Opacus Metal 27
Milli-Volt and Micro-Ampere Relay 693
Moisture Balance, Wood 37
Monochromators, Van Cittert's Double 206
Motor for Small Appliances, New Series Universal 642
Motor Starter, Float Operated 574
Nephelo-and Absorptiometers for White and Monochromatic Light 208
Operation Recorder 609
Oscillograph, Automatic 362, 459
Oscillograph and Recording Camera, String 409
Output Meter 195
Parr, Samuel Wilson 374
Permeability Determination 475
Phase Indicator, Portable 244
Photoelectric Cell 641
Photoelectric Cell, Quartz 628
Photoelectric High Temperature Measurement and Control 557
Photoelectric Lighting Control Relay 523
Photoelectric Recorder 403
Photoelectric Relay 702
Photoelectric Relay Operates for Cutting Hot Bars in Rolling Mill 570
Photoelectric Tube Makes It Possible to Locate Airport in Fog Flying 405
Pivots, Instrument 105
Potentiometer, Improved L & N 505
Potentiometer, Precision 459
Potentiometer, Pyrometer 353
Potentiometer, Thermocouple 559
Pressure Device, Power Type 288
Pressure Gage, New 35
Pressure Gage, All-Steel 632
Pressure Gage, Mercury Column 401
Pressure Gages, Multi-Contact Making 513
Pressure Measuring Instruments 17, 55, 143, 225
Projector, Combination 256
Protective Relays 121
Pulsation Dampener 572
Pulsation Shock Absorber 461
Push Button Master Station 30
Pyrometer Control, Indicating 250
Pyrometer, Optical 407
Pyrometers, Tapalog Recording 355
Rapid Recorder 627
Recording Gages, Steel Spring 37
Relay, Indoor Lighting Control 515
Relay, Outdoor Lighting Control 509
Relays, Dunco Mid-Gett 460
Relays for Use with Light Sensitive Cells 29, 698, 702, 703
Relief Valve, Hydraulic 639
Rheostat, Improved Tubular 46
Rotarule 251
Round-O-Meter 116
Salinity-Indicator System 455
Scale, Convert-O-Matic 516
Scale, Sensitive 456
Scales—See Balances ..... .
Scales, Fluid Pressure 17
Sheet Metal Tester 512, 571
Slide Rule, Circular 251
Slide Wire Model Control 48
Smoke Indicator 621
Smoke Recorder 204
Snap Gages, Flat Plug and Shoulder 138
Space Heater Protects Control Apparatus 578
Specific Gravity Meter, Gas 623
Speed and Acceleration Measurements 377, 413, 389, 541, 581, 647
Speed Indicators 413
Split-Core Current Measuring Set 619
Spring Testing Machine 640
Spring Testing Machine, Elasticometer 362
Springs, Instrumen.t 173
Starter, Oil-Immersed Thermaload 296
Steam Trap 466
Strain Gage, Impact 265
Strain Gage, Magnetic 200
Strain Gages 202
Stretch and Shrinkage Testing Apparatus 360
Stroboscopes 581
Surveying Instrument, Route 624
Switches, Time 309
Tachometers, Centrifugal Fluid 439
Tachometers, Centrifugal Weight 428
Tachometers, Chronometric 423
Tachometers, Electric 489
Tachometers, Magnetic Drag 500
Tachometers, Positive Pump 545
Tachometers, U-Tube 543
Tachometers, Viscous Drag 502
Tachoscopes, Combined 418
Tachoscopes, Vibration 553
Tackiscope 119
Tape-Rule, Crescent 406
Temperature Regulator 567
Tensile Testing Machine 307
Tension Indicator 569
Test Water Cooling Coils 245
Testing Apparatus and Machines 299, 369
Testing Kits, Portable 255
Testing Oil, Portable Equipment for 243
Theodolite, Tavistock Transit 400
Thermal Converter 471
Thermometer Fixture, Wet and Dry Bulb 288
Thermometer, Wash-Wheel 117
Thermostat, New Radiation 631
Thread Checking Gage 290
Thread Snap Gage 33
Thyratron Tubes, Rubber Conveyors are Synchronized by 470
Time Controller, Non-Recording 574
Time-Cycle Regulator 127
Time Meter, Direct Reading 463
Timepiece, Automobile 562
Time Switch 36, 521
Time Switch, Sauter Electric 294
Timer for Individual Vulcanizers 245
Timer, Work-Cycle 43
Timers, Indicating and Recording 309
Timing and Scheduling Instruments 279, 309
Transit-Level 254
Tru-Vac Gage 518
Turbidimeter 114
Type Contact Pyrometer 575
U-Tube, Damping 132
U-Tube Manometer 64, 200
Ultra-Violet Radiation Indicator 44
Universal Testing Machine 395, 701
Vacuum Contact 358
Vacuum Contact Mounting 627
Vacuum Thermocouple for Alternating-Current Reading 558
Vacuum Thermocouples for Measuring Weak Alternating Currents 472
Valve, Motor Operated 700
Valve, Solenoid 410
Valve Solenoid Operated 510
Vibracorder, Ohmer-Kienzle 257
Vibration Meter, Miniature Porable 402
Vibroscope 125
Viscosimeter, Automatic 519
Viscosity Tube, Collins 261
Volt-Ammeter for Airplane Battery Circuits 113
Volt-Ohmmeter, Direct Current 117

Water Level and Pressure Gage, Micrometer ... 467
Watthour Meter, Recording Demand ... 468
Weighing Device, Cut Off ... 123
Weightograph, Howe ... 290
Weight Car, Motor Driven ... 293
Weights—See Balances ... ...
Weights ... 3, 213
Wire Gage ... 506
Working Viscosity ... 193
X-Ray Tube, Powerful ... 365

AUTHOR INDEX

American Askania Corp ... 251
American Instrument Co ... 123, 698
American Transformer Co ... 243, 295
Amthor Testing Instrument Co ... 401,506, 699
Andree Dr. Clarence Alois ... 265
Anglo-Swiss Electrical Co., Ltd ... 402
Askaniawerke ... 576
Automatic Maintenance Machinery Co ... 116
Automatic Temperature Control Co ... 700
Bailey Meter Company ... 39,124,288,516, 694
Baldwin-Southwark Corp ... 111, 133, 249, 571
Bausch & Lomb Optical Co ... 522
Behar, M. F ... 17, 55, 143, 173, 225, 279, 309 ... 377,413,489,541,606, 647
James G. Biddle Co ... 199
Bodine Electric Company ... 642
Brevoort, M. J ... 277
Bristol Company ... 288, 398, 563
Brown Instrument Co ... 205, 353
Burgess Battery Company ... 358,464,627, 703
Burgess, Jackson ... 374
Burgess-Parr Co ... 114, 197, 509, 512
Burton-Moore & Lush ... 198
C. F. Casella & Co., Ltd ... 467
Champion & Barber ... 567
Chapman, Cloyd M ... 527
Cincinnati Electrical Tool Co ... 122
Clay-Adams Co ... 27, 404
Coats Machine Tool Co ... 362, 640
Collins, Arthur ... 261
Consolidated Ashcroft Hancock Co., Inc ... 259
Continental Electric Co ... 518
Cooke, Troughton & Simms, Ltd ... 400
Cramer & Company., Inc., R. W ... 294
Crawford, John D ... 409
Crosby Steam Gage & Valve Co ... 632
Cutler-Hammer, Inc ... 574
Daun-Walter Company ... 250
Dempster, J. R ... 251
Detroit Testing Machine Co ... 512
DeVilbiss Co ... 258
Donner, Robert ... 119
Durant Mfg. Co ... 461
Echometer, G.m.b.H ... 643
Electro Gas Development Co ... 631
Electrocon Corp ... 125
Ellison Draft Gage Co ... 457
Englehard, Inc., Charles ... 625
Esterline-Angus Co ... 565
Etna Electric Works ... 693
Fahy, Frank P ... 475
Federal Products Corp ... 248, 290, 506
Ferner Co., R. Y ... 41,137,359,465,514, 692
Foxboro Company, The ... 35, 37, 109, 117, ... 132,198,408,574, 697
Gaertner Scientific Corp ... 507
General Electric Company ... ... 54, 118, 129, 130, 211, 255, 294, 362, 365, 403, 459, 463, 469, 509, 510, 515, 521, 557, 558,559,570,634,635,701,702.
General Electric Incandescent Lamp Dept ... 44
General Electric Research Laboratory ... 405
General Radio Co ... 409
G-M Laboratories, Inc ... 30, 628
Goodrich Co., B. F ... 470
Hammond, H. M ... 694
Hardwick, Hindle, Inc ... 46
Harrison, Thomas R ... 353
Hazeltine, H. L ... 193
Hein, Jr., C. C ... 292
Hevi Duty Electric Co ... 136
Heyde, Gustav ... 135, 624
Howe Scale Co ... 290
Hutchison, Miller Reese ... 47
Illinois Testing Labs. Inc ... 575
Jaeger Watch Co., Inc ... 562
Johnson, C. V ... 33
Kipp, P. J. & Zonen ... 206, 208, 472
Krogh, A. E ... 205
Kuttner, J ... 519
Leeds & Northrup Co ... 204, 505
Lehmann & Michels ... 291, 292
Leitz, Inc., E ... 256, 262
Leonhardt, Rene ... 576
Lincoln Meter Co., Inc ... 471
Littlefuse Laboratories ... 115
Luckey, George P ... 532
Lush, A. J ... 105
Lufkin Rule Co ... 406
MacGahan, Paul ... 244
Paul Maehler Company, The ... 128
Martin-Decker Corp ... 569, 572
Meriam Co ... 200, 461
Metzger & Son, F. F ... 202
Monitor Controller Co ... 30, 43, 296
Nichols, J. T ... 307
Ohmer Fare Register Co ... 257
Olsen, Tinius Testing Machine Co 628, 629, 630
Ower, E ... 182,445,480,533,607, 663
Pease Co., C. F ... 626
Permutit Company ... 31, 401, 623
Peterson, A. J. A ... 51
Pittsburgh Equitable Meter Co ... 638
Pratt and Whitney Company ... 33, 507
Pyrometer Instrument Co ... 627
Refinery Supply Co ... 700
Riehle Bros ... 32, 395
Rimbach, Richard ... 213, 369
Roller Smith Company ... 117
Rubicon Company ... 110, 619
Sales Corporation ... 621
Sangamo Electric Co ... 36, 259
Sarco Co ... 567
Scherr Co., George ... 360
Schniewind, H. Z ... 360, 397
Schroder, Arthur ... 3, 87
Scientific Instrument Co ... 196
Seederer-Kohlbusch, Inc ... 260
Siemens & Halske ... 407
Southwark Foundry & Machine Co 111, 133, 249, 571
Sperry Gyroscope Co., Inc ... 455, 462
Stephens-Adamson Mfg. Co ... 293
Sticht & Co., Herman H ... 48, 633
Struthers-Dunn, Inc ... 460, 637
Sundt, E. V ... 115
Suter, Alfred ... 357
Taft-Pierce Mfg. Co ... 138, 396
Tagliabue Mfg. Co., C. J ... 245, 287, 466, 561
Taylor Instrument Companies ... 127, 248, 250
Taylor & Co., Inc., W. A ... 126, 568
Timken Roller Bearing Co., The ... 253
Tinius Olsen Testing Machine Co ... 701, 704
Toledo Precision Device, Inc 121, 123, 132, 364, 410
Toledo Scale Co ... 293, 456, 463, 511, 516
U. S. Forest Products Laboratory ... 37
Veeder-Root, Inc ... 247
Vickers, Inc ... 639
Visco-Meter Corporation ... 195
Viscosity Engineering Corp ... 519
Walser Automatic Timer Co ... 641
Warren-Knight Co ... 254
Wells Mfg. Co ... 458
Westinghouse Electric & Mfg. Co ... ... 113, 121, 131, 200, 244, 292, 459, 468, 513, ... 523, 573, 578, 620, 622, 632, 644
Weston Electrical Instrument Corp ... 29, 641
Wilson-Maeulen Co., Inc ... 355
Wollensak Optical Co ... 127

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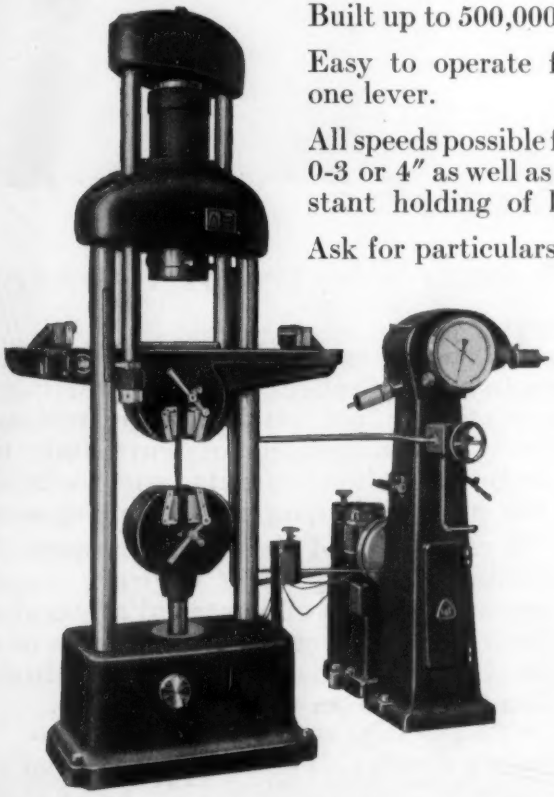

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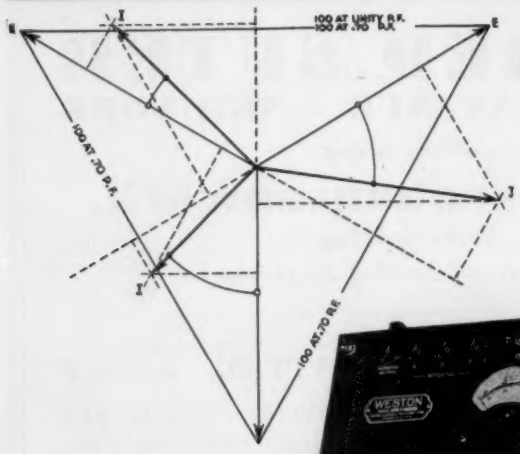

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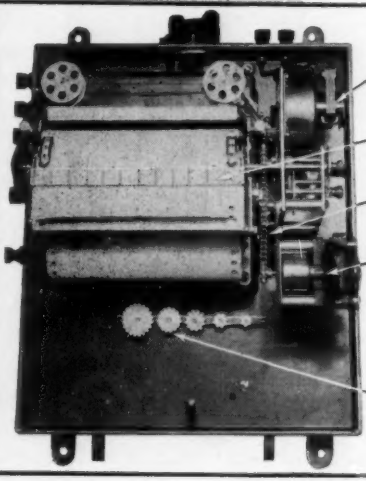
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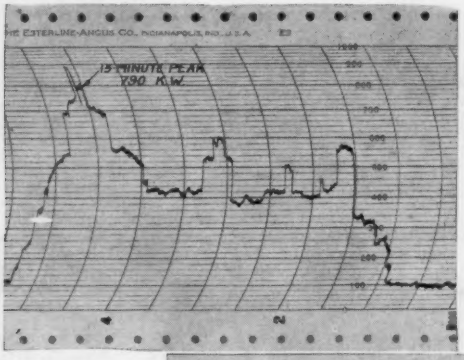

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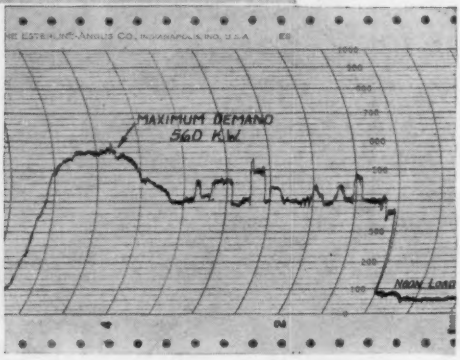
and

AFTER



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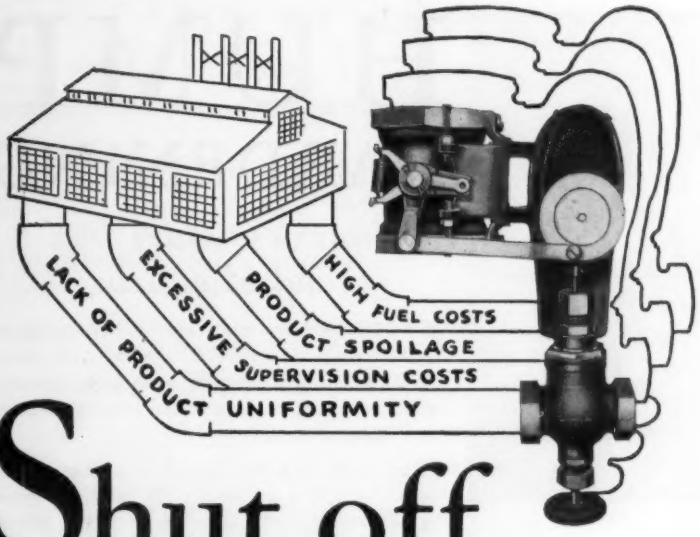

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TABLE OF CONTENTS

JANUARY, 1931

Editorial Comment 1
The Handbook of Laboratory Instruments
Instrument Developments in 1930
The Outlook for 1931
Classifying Variable Pressures—and Instruments Therefor
Engineering Progress

Handbook of Laboratory Instruments and Apparatus— 3
Arthur Schroder

Handbook of Industrial Instruments—M. F. Behar 17

New Instruments
"Opacus" Metal Microscope ... 27
Relays for Use with Light Sensitive Cells ... 29
Photoelectric Relay ... 30
New Push Button Master Station ... 30
New CO_2 Indicator and Recorder ... 31
New Mirror Extensometer ... 32
Thread Snap Gage ... 33
New Pressure Gage ... 35
New Time Switch ... 36
Steel Spring Recording Gages ... 37
Wood Moisture Balance ... 37
Bailey Meters and Control ... 39
Universal Two-Co-ordinate Measuring Machine ... 41
Work-Cycle Timer ... 43
Ultra-Violet Radiation Indicator ... 44
New Electric Gage ... 45
New Improved Tubular Rheostat ... 46
New Exhaust Gas Analyzing Device ... 47
Slide Wire Model Control Transformer ... 48

Catalogue Library ... 11
Book Shelf ... 14
Current Literature Review ... 16
Buyers' Guide ... 18
Advertisers' Index ... 27
Index Card Section ... 28

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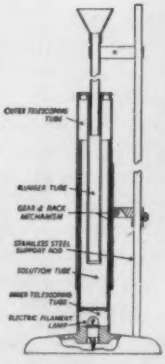

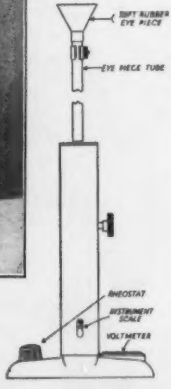

Above: photograph showing method of operation. Left and right: descriptive illustration of turbidimeter showing construction and mechanical details.

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EDITORIAL COMMENT

The Handbook of Laboratory Instruments.

IT is with pleasure and pride that the managing editor calls attention to the initial instalment of this new work on page 3. Mr. Arthur Schroder, its author, is no stranger to our readers, having contributed several articles, among them the "Review of Laboratory Instruments in 1929" just a year ago. As in the case of the companion work on industrial instruments, which also appears serially in INSTRUMENTS, we feel that the one man best qualified for the particular job has undertaken it. Mr. Schroder is Director of Technical Service of the Fisher Scientific Co. and has had intimate experience with laboratory and scientific instruments and apparatus. Like Mr. Béhar he has not only written about instruments but has worked with them.

Mr. Schroder's book, we believe, fills an even greater need than that filled by our industrial instrumentation manual, for up-to-date non-commercial yet practical information on laboratory equipment is even scarcer—in proportion to the need of it—than the current literature on plant control instruments. This assertion seems unfounded until one has begun to read through Mr. Schroder's treatment of the subject, which affords a revelation in its wealth of heretofore unpublished or thinly-scattered material. Now that research has attained such far-reaching importance, the appearance of the Handbook of Laboratory Instruments is of the utmost timeliness.

Instrument Developments in 1930

Like all reliable instruments that obey known physical laws, INSTRUMENTS bows to the law of supply and demand in discontinuing the annual reviews of new instruments which featured the January, 1929, and January, 1930, numbers. While these articles were undoubtedly useful, they were to some extent repetitions in that many of the instruments discussed in these annual reviews had already been described in our monthly "New Instruments" sections. It was therefore decided several months ago to do away with the necessity of annual articles by making the twelve monthly "New Instruments" sections constitute a much more detailed review of progress. Having made an effort to determine our readers' opinion before taking this step, we feel certain that they will approve it. The absence of a formal arrangement into such headings as "Industrial," etc., is more than made up by the greater completeness of the individual descriptions. A glance through the tables of contents of the twelve issues ending with this one shows that 1930 has indeed been a fruitful year for the instrument industry.

The Outlook for 1931

When one considers the really significant happenings of the year just ended, it is plain to see that the instrument industry has much to be thankful for, little to complain about, and vast possibilities to cultivate in 1931. In spite of the general business depression, the march of scientific and technological progress continued steadily. In all industries new methods were introduced and most involved instrument applications. The fields

of pure and of applied research continued to demand the contributions of instrument manufacturers. Surveying, the geological sciences, astrophysics, even medicine, hailed new and improved models from the instrument makers' shops. In times of stress wise men always seek the One Best Way, and so it was in 1930: the trend toward higher accuracy of measurements, and the extension of automaticity, were both manifest. INSTRUMENTS expects this healthy course to continue; and confidently predicts that wherever wise men have led in 1930, others will follow in 1931. In short, since there was no decline in the demand for instruments last year, there should be a great increase this year.

Classifying Variable Pressures—and Instruments therefor.

In his December article our engineering editor suggested that systematic classifications of variable pressures be undertaken and officially promulgated. He laid down in brief several methods of such classification. He pointed out the resulting convenience of being able to purchase, for each application, an instrument which would not only be of the right range but of correct damping with regard to the particular "class" of fluctuations. To the best of our knowledge, no such proposal had ever been made before. Among others, Mr. F. G. Tatnall, Engineer, Baldwin-Southwark Corporation, comments as follows:

> I am amazed at the accumulation and the classification of data which you have here, which far surpasses anything I have ever seen on pressure work.
>
> Regarding your advocacy of engineering classification of variable pressures, my only comment on this is it should have been in bold face type under a special heading instead of obscured by small type. Your suggestion would give a basis of standardization which all manufacturers of pressure equipment would welcome and which would add a prop of stability to the whole business of pressure measurement which is lagging behind electrical measurement, although it is as important.
>
> The difficulty of investigating the suitability of apparatus by purchasers adds to the cost of sales and brings general confusion continuously, especially in our type of work which is rather technical and not so standardized. See if you cannot say more about this engineering classification and we manufacturers will all be ready to chime in.

INSTRUMENTS desires to hear from all interested sources. We hope that pressure instrument manufacturers, engineering societies, research organizations and individual engineers will send in their comments. We will gladly assemble them and publish a symposium in an early issue, after which we will gracefully step out of the picture and let the situation be handled by whatever official body takes hold of it. Capt. Béhar's proposal appears in last month's issue, pages 761 to 764.

Engineering Progress

The annual meeting of the American Society of Mechanical Engineers in December furnished a striking demonstration of the relation between engineering progress and advances in measurement technique. Among the many features of the convention involving descriptions of new or refined or "codified" methods and means of making physical measurements, we need only mention two: (1) A new report of the Committee on Instruments and Apparatus, dealing with Calorimetry of Fuels, which is reviewed in INSTRUMENTS (2) The appearance of a revised edition of Part One of the Fluid Meter Report—that veritable "condensed bible of flow measurement."

(Continued on Page 26)

Handbook of Laboratory Instruments and Apparatus

*Arthur Schroder**

INTRODUCTION

WHEN a consumer orders a bill of goods "the same as the last," he automatically writes a specification into that order. At times the goods are received and rejected as not being the same because "the parts received do not fit into parts made in another city" or "the color does not match." When this happens, the question of just what is the difference is immediately raised. No amount of talk can settle such disputes—but a few measurements on a correct gage or colorimeter, as the case might require, usually will. Differences as to reproducibility are then based on fact, and "facts tolerate no arguments." The establishing of such facts necessitates the use of instruments, and the instruments then become the common language of fact between the producer and consumer.

Technical progress in the last decade has been due, to a large extent, to the development of new and more accurate mechanical devices or instruments for the measurement of time, the distribution of energy and the testing of the properties of matter. As instruments become more highly refined products are made more nearly alike, mass production is speeded up and the cost to the ultimate consumer reduced. Practically all the large industries control their outputs by technical means. Many have well established methods of tests and have standardized on the apparatus to be employed. Some industries operate individual or even group research laboratories. But in others little is being done. In all, there is the need for testing equipment.

In plant control as well as in research work, every testing problem presents difficulties as to the method to be used in solving it. After the method has been decided upon, the selection of suitable apparatus for carrying out the method often proves to be a problem in itself. The choice of method will not be discussed here. That will be left to the engineer or chemist immediately concerned. We will, however, describe the various types of instruments available to the technical man, so as to aid him in his selection of the apparatus, treating the methods as incidental.

*Technical Director, Fisher Scientific Company.

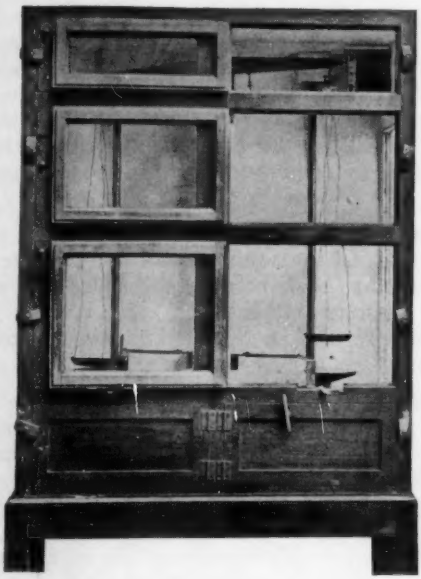
One is frequently at sea as to where to look for information on the various types of instruments and apparatus available for a particular purpose. Quite true, manufacturers' catalogues and trade literature contain much, but these of necessity must be limited in scope. Technical magazines have offered some relief, but in these, descriptions of the testing equipment have usually suffered for want of space and the authors' greater interest in the results obtained rather than in the means whereby the results were made possible. Yet how frequently is one confronted with the need of measuring some property of a substance and after searching the literature feels that no suitable equipment is available. This book, it is hoped, will serve as a guide to the increasing number of laboratory apparatus and instruments now commercially available, and in some cases, while not produced commerically are at least procurable.

Each industry has developed its own group of testing equipment. Many industries have standardized on the same equipment for many tests common to them, but how many instruments now considered specific in their application to one industry could be used to great advantage in other industries. Some slight change might at times be necessary, but the underlying principle could frequently be adopted without much modification. The data here presented, have been arranged with this in mind, and probable uses of instruments in new fields have been indicated. Other possible uses will occur to the reader.

In compiling the data, it was recognized that several instruments are frequently available for the same purpose. Preference has always been given to those which have been adopted as standard by the U. S. Bureau of Standards (or the foreign equivalent), the American Society for Testing Materials and similar technical associations, trade associations and to such, which, although not officially adopted as a standard have gained through their widespread use in industries all the authority of standards. Referee items have been given preference but the equivalent "short-cut" apparatus of approximate but adequate accuracy is indicated wherever possible. No attempt has been made to include such items as has been recommended in the literature for one specific research problem and which have very little general applicability.

As an instrument is essentially a mechanical device used to measure some property of matter, there can be no definite line of demarcation between an instrument and an apparatus which consists of a group of instruments so cooperating as to produce the same type of result. It was with this in mind and for the sake of completeness, that much, ordinarily considered as apparatus, has been included. The purpose of this book is to make available to the technical man, be he testing engineer, plant superintendent, chemist, physicist, teacher or student, essential data on modern laboratory testing instruments. Realizing that the time of such men is usually at a premium, historical matter, interesting as it may be, has been deliberately omitted.

As far as we are aware, this is the first book of its kind, so errors of ommission and commission are bound to be found. Its deficiencies may be many. It is offered in the spirit of a helping hand, when no other is available. The author will appreciate being advised of any errors and will welcome any suggestions for increasing its value to the readers.



CHAPTER I.

BALANCES, SCALES AND WEIGHTS

At left one of the earliest analytical balances, designed and built by Henry Cavandish (1731-1810) (*Fisher Scientific Co.*)

SINCE the weight of a substance is the fundamental knowledge on which all business is transacted, the instruments for measuring weight are the basic tools of the technical man. The styles of balances and scales are almost as numerous as the users, but the types can be classed into a few groups depending on structural differences and the uses to which they are put. Modern usage tends to differentiate between the balance and the scale. In the balance the pans are hung below the fulcrum or center of rotation, and in the scale the pans are above, although some manufacturers still call their balances scales and others call their scales balances. As a rule balances are more delicate and are used for weighing smaller amounts of material than scales. Most balances will accurately weight to one part in a million, while scales are usually accurate to about one part in two hundred, with exceptions of course.

In selecting a weighing instrument the capacity of the balance or scale should never be greater than necessary, for the greater the capacity the less the sensitivity and accuracy.

CAPACITY is understood to mean the maximum load, in each pan, that the balance or scale is capable of carrying without injury and without loss of sensitivity. Many balances are sold with one sensitivity at one capacity and another (usually about half as great) at twice the capacity. This is done to satisfy a demand for a balance for routine work of limited capacity and reasonable price with the possibility of using the balance for an occasional heavier load,—and without the more expensive refinements of construction necessary for the additional sensitivity.

SENSITIVITY. No official definition has been established for the terms sensitivity and sensitiveness. They are both used synonymously to indicate the degree of unbalance caused in a balance or scale when a given minimum weight is added to a pan. Thus the statement "0.1 mg. sensitivity" is meaningless unless amplified as to how much the balance is thrown out of equilbrium by the 0.1 mg. To clear up the situation—some, but not all, manufacturers are now modifying their specifications to include this as "the indicator swinging 2.5 divisions on the index scale with a load of 1.0 mg." In this case the sensitivity would mean 0.1 mg. causes a displacement corresponding to 0.25 divisions. Obviously the length of the divisions must be specified. This is now fairly well standardized at 1 mm.

SENSIBILITY RECIPROCAL, on the other hand, has been defined by the U. S. Bureau of Standards, as the weight required to cause a change in the position of rest of the pointer equal to one division of the graduated index. This term is usually applied to trade balances and scales such as prescription, cream test scales, moisture test balances, etc. Practically all states where weight and measure regulations are enforced have adopted the term sensibility reciprocal.

The sensitivity of a balance varies directly as the length and inversely as the weight of the beam. Thus in selecting a balance, the longer and lighter in weight the beam, the more sensitive will be the balance, all other things being equal. The period of oscillation or time consumed in making a complete swing is important from the time consuming viewpoint. Balances with the center of gravity of the beam below the knife edges are faster, but less sensitive than those with the center of gravity above the edges, and vice versa. Maximum sensitivity with optimum period of oscillation is obtained with the center of gravity in the same plane as the knife edges. Most analytical balances have small adjustable slide weights attached to the indicator arm for changing within limits, the center of gravity to suit conditions.

ANALYTICAL OR CHEMICAL BALANCES

No attempt will be made to describe any one specific analytical balance as there are many different makes of the same type available on the market today. Instead, a typical one will be described, the variations from the standard being indicated as necessary. They are all of the equal-arm beam type, see Fig. 1, with the fulcrum supported by a column attached to the balance base, and enclosed in a glass case to protect them from drafts.

The beam of the analytical balance is usually of aluminum alloy, rolled not cast, and drilled or stamped out into the shape of a structural girder for maximum strength with minimum weight, so that the actual mass of metal in motion during weighing shall be at a minimum. The new balances have aged beams or beams which have been permitted to lie in storage for some time after the heavy drilling and working in order to permit any strains set up in the metal to become relieved before final finishing and polishing. This eliminates warpage of the beam during service and makes for greater constancy in use. The beam is usually graduated into 50 or 100 divisions each corresponding to 0.1 mg. Beams graduated into 100 divisions per 10 mg. load, take a 10 mg. rider while those graduated into 50 divisions per 5 mg.load, take a 5 mg. rider.

The edges and knife edge bearing planes are of the finest available agate (Brazilian and Russian agates are considered best) and are ground to an angle

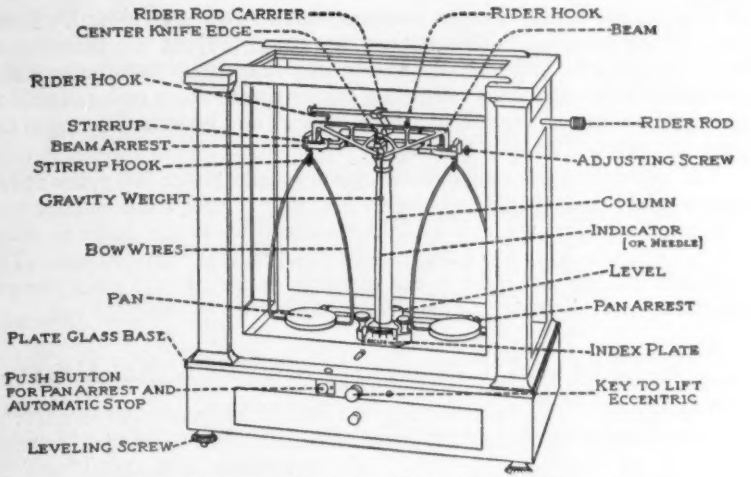


Fig. 1. Principal Part of the Analytical Balance (*Christian Becker, Inc.*)

Fig. 2. Typical Analytical Balance with Bureau of Chemistry Pan Supports. (*Fischer Scientific Co.*)

of 60° for the main body of the bearing with the knife edge itself ground to an angle of about 120° (the lower 1/8", on which the load of the balance actually rides). The planes on which the knife edges rest are of agate in the better balances, but in the cheaper and less sensitive balances these are frequently made of some hard steel or stainless steel alloy.

The beam releasing arms in the better balances are so constructed that the beam is lifted from the bearings as a unit, the bearings in the stirrups being released at the same time. For releasing the beam, the beam arrest mechanism falls away from the beam, each arm of it rotating through an arc the radius of which is equal to the half length of the balance beam. These arms have conical centering lugs which fit into corresponding sockets on the beam and stirrups and automatically replace the beam on center each time it is released. Pans and arches are made of different materials, usually brass or steel and are nickel or chromium plated. The newer balances have the Bureau of Chemistry type of wide arch supported from a broad flat sheet of metal at the top, with the pan-suspending rods straight rather than bent or bowed as in the older balances. This gives more "head room" necessary when weighing combustion bulbs, absorption apparatus, etc.

The cases of most balances are of wood, mahogany being preferred, although one manufacturer is now making a line of balances with aluminum frames which are said to be free from the warping due to absorption of moisture by wood in humid atmospheres. Front and back doors are counterpoised, while ends are usually not removable. Base plates are black glass

or slate except in the cheaper balances where wood is employed. Most balances are provided with extra pan arrests to prevent the swinging of the pans during loading and immediately after releasing. Some balance stirrups carry wire extensions below the pan carriage, which swing in slots in the pan arresting device and prevent a forward and backward swing of the pans and so speed up the weighing.

The capacity of the analytical balance is usually 100 or 200 grams at full load, a good balance being sensitive to 1/10 mg. Other balances have that sensitivity at only one half load (the control laboratory balance) while others have still less, depending on construction and intended use. The "Student Balance" is similar to the analytical balance but of much cheaper construction throughout and usually of a sensitivity of about 1/5 mg.

THE CARE OF THE MODERN ANALYTICAL BALANCE*

The beam (6″) of a balance carrying a load of 200 grams and sensitive to 0.1 mg. must be adjusted so that the arms A and B (Fig. 3) are equal to within a tolerance of .00001″ and the edges in a horizontal plane and paralleled to within .0001″ and the center of gravity (C) of the beam just sufficiently below the horizontal plane through the edges (CL) to insure stable equilibrium.

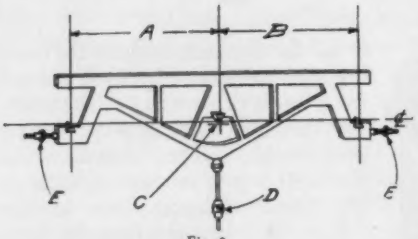


Fig. 3

If the center of gravity lies in the horizontal plane (CL), the indicator will stand in any position on the index when in balance; if the center of gravity is above this plane, the indicator will not return to zero but will remain at either extreme of its movement.

The contact lines of the agate edges must be flat and highly polished so as to offer a continuous unbroken line of contact, as shown by F. (Fig. 4).

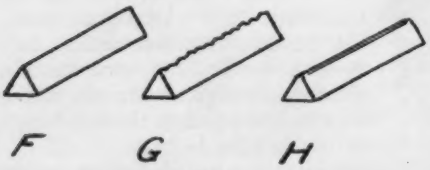


Fig. 4.

If the edges or planes are not highly polished, a contact line (G) will be produced which will quickly break down under load until a rounded contact surface (H) will result, when the balance will lose its sensitivity through increased friction between the edge and plane. Accuracy will also be lost through the rolling of the plane on the rounded edge, thereby varying the length of the arms of the beam as it swings; the falling arm decreasing in length as the rising arm increases.

For these reasons, balances should have their edges and planes repolished from time to time and the work should be done by an expert. After repolishing the edges and planes, the beam must be readjusted.

Cleaning—In cleaning the balance, remove the hangers and stirrups, and taking hold of the indicator, just below the beam, lift the beam slightly and lower the releasing mechanism after which, one end and then the other may

*This section reprinted from *The Laboratory*, Vol. 1, No. 4, page 61 (*Fisher Scientific Co*)

be lifted from the yoke supporting the stirrups; the beam can then be removed from the bearing at the center. Be careful not to strike the agate edges or to bend the long indicator attached to the beam.

Brush the beam with a soft camel-hair brush.

Clean the agate edges and planes with soft tissue paper (cloth may leave lint) moistened with alcohol or gasoline. Do not touch the beam or other lacquered parts with alcohol as it will remove the lacquer.

With a tooth brush, vigorously brush out the grooved supports which carry the agate edges of the stirrups when the balance is arrested. Collected dirt in these grooves causes the stirrups to stick and release unevenly.

Wipe the glass surfaces of the base and case with a chamois; wool or silk cloths will produce "static."

Use the least possible amount of light high-grade oil on metal bearings and sliding contact surfaces of the pan-arrest mechanism and the beam-release mechanism. More oil than is necessary will collect dust and become sticky and is more objectionable than no oil at all. Use no oil on the agate bearings.

Reassemble the balance and be sure that the beam is resting on its contacts on the releasing mechanism. If the indicator has not been bent then the only adjusting which might be required is that of the balancing screw-weights at the ends of the beam.

Simple Precaution—Precise weighing should be made with the beam swinging a division or more from zero, for the reason that it requires less effort to keep a body in motion than it does to overcome its inertia; also, it will indicate that there is nothing impeding the swinging of the moving parts.

The Use of Drying Agents—The question of humidity within the balance case is controversial. The author believes, that if properly located, the balance is best kept without a drying agent. Sulphuric acid in a beaker will give off some acid fumes, it tends to increase in volume and is liable to overflow and it becomes an ineffective absorbent unless stirred regularly and changed often.

Calcium chloride is a somewhat better agent but it too, has some of these drawbacks. The principal use of a dryer in a balance case is to keep the sample being weighed in dry atmosphere and even though it keeps the interior of the case dry, the atmosphere is almost instantaneously balanced when the case is opened for weighing. The author thinks it better in such weighings to use the stoppered weighing bottle.

In locations where the humidity is high, static electricity gives but little trouble unless the balance case has just been cleaned, in which event the case will become charged with "static" which must be discharged by breathing on the glass or touching it with moistened fingers. In the usual laboratory, water and steam baths, open sinks, etc., produce sufficient humidity to minimize the effect of "static" on the balance.

In very dry locations, it is sometimes necessary to ground the glass of the case and the metal work of the balance by running a wire to a water-steam or gas pipe. Connection with the glass may be made by cementing tin or lead foil on the glass surfaces. A small piece of carnotite or other radio active substance placed in a corner of the balance case has been found very effective as a preventative of static charges.

or slate except in the cheaper balances where wood is employed. Most balances are provided with extra pan arrests to prevent the swinging of the pans during loading and immediately after releasing. Some balance stirrups carry wire extensions below the pan carriage, which swing in slots in the pan arresting device and prevent a forward and backward swing of the pans and so speed up the weighing.

The capacity of the analytical balance is usually 100 or 200 grams at full load, a good balance being sensitive to 1/10 mg. Other balances have that sensitivity at only one half load (the control laboratory balance) while others have still less, depending on construction and intended use. The "Student Balance" is similar to the analytical balance but of much cheaper construction throughout and usually of a sensitivity of about 1/5 mg.

THE CARE OF THE MODERN ANALYTICAL BALANCE*

The beam (6″) of a balance carrying a load of 200 grams and sensitive to 0.1 mg. must be adjusted so that the arms A and B (Fig. 3) are equal to within a tolerance of .00001″ and the edges in a horizontal plane and paralleled to within .0001″ and the center of gravity (C) of the beam just sufficiently below the horizontal plane through the edges (CL) to insure stable equilibrium.

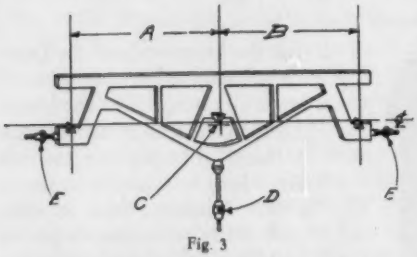


Fig. 3

If the center of gravity lies in the horizontal plane (CL), the indicator will stand in any position on the index when in balance; if the center of gravity is above this plane, the indicator will not return to zero but will remain at either extreme of its movement.

The contact lines of the agate edges must be flat and highly polished so as to offer a continuous unbroken line of contact, as shown by F. (Fig. 4).

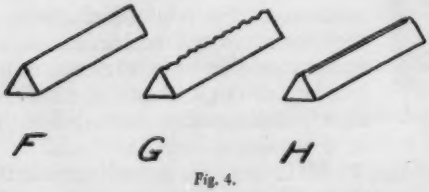


Fig. 4.

If the edges or planes are not highly polished, a contact line (G) will be produced which will quickly break down under load until a rounded contact surface (H) will result, when the balance will lose its sensitivity through increased friction between the edge and plane. Accuracy will also be lost through the rolling of the plane on the rounded edge, thereby varying the length of the arms of the beam as it swings; the falling arm decreasing in length as the rising arm increases.

For these reasons, balances should have their edges and planes repolished from time to time and the work should be done by an expert. After repolishing the edges and planes, the beam must be readjusted.

Cleaning—In cleaning the balance, remove the hangers and stirrups, and taking hold of the indicator, just below the beam, lift the beam slightly and lower the releasing mechanism after which, one end and then the other may

*This section reprinted from *The Laboratory*, Vol. 1, No. 4, page 61 (*Fisher Scientific Co*)

be lifted from the yoke supporting the stirrups; the beam can then be removed from the bearing at the center. Be careful not to strike the agate edges or to bend the long indicator attached to the beam.

Brush the beam with a soft camel-hair brush.

Clean the agate edges and planes with soft tissue paper (cloth may leave lint) moistened with alcohol or gasoline. Do not touch the beam or other lacquered parts with alcohol as it will remove the lacquer.

With a tooth brush, vigorously brush out the grooved supports which carry the agate edges of the stirrups when the balance is arrested. Collected dirt in these grooves causes the stirrups to stick and release unevenly.

Wipe the glass surfaces of the base and case with a chamois; wool or silk cloths will produce "static."

Use the least possible amount of light high-grade oil on metal bearings and sliding contact surfaces of the pan-arrest mechanism and the beam-release mechanism. More oil than is necessary will collect dust and become sticky and is more objectionable than no oil at all. Use no oil on the agate bearings.

Reassemble the balance and be sure that the beam is resting on its contacts on the releasing mechanism. If the indicator has not been bent then the only adjusting which might be required is that of the balancing screw-weights at the ends of the beam.

Simple Precaution—Precise weighing should be made with the beam swinging a division or more from zero, for the reason that it requires less effort to keep a body in motion than it does to overcome its inertia; also, it will indicate that there is nothing impeding the swinging of the moving parts.

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Location—It is obvious that balances should be mounted in a way that obviates vibrations; the support extending through the floor into the ground is the best. If this is not possible, then it is better to bolt the support to a substantial wall.

A separate room for balances provides a means for protecting the balances from fumes, but in many control laboratories the inconvenience and time lost in going back and forth to the balance room for each weighing is an objection.

In one laboratory, the cost of the time used in trips to and from the balance room was calculated and found to be more than the cost of a new balance each year.

A balance cover made of rubberized cloth is a good dust and fume protector and the habit of placing such a cover over the balance when it is not in use, should be cultivated, especially so, as the laboratory is usually dusted and cleaned when the balances are not in use.

MICRO ANALYTICAL BALANCE

A special size of the analytical balance has made its appearance within the last few years, which holds promise of revolutionizing the chemical laboratory, that is the micro balance. It (the Becker model) has a capacity of but 25 g. with a sensitivity of 0.001 mg. or about one 25 millionth of an ounce. The beam is 4″ long and made of hard rolled aluminum alloy. It is graduated from left to right in 100 notched divisions with a range of 0 to 10 mg., each notch corresponding to 0.1 mg. The balance is in equilibrium when the 5 mg. rider is at the zero mark. The pointer swings 10 full divisions on the index for each 0.1 mg. on the beam, each division corresponding to 0.1 mg. Each division is subdivided into 0.005 mg. by means of the index lens, the position of the pointer can be read to 0.001 mg. The arrest arms have the same axis of rotation as the beam so as to eliminate sliding of the knife edges on the bearings. Knife edges and bearing plates are of agate. Balance is supplied with a plano-cylindrical lens for facilitating reading of the beam and circular lens for the pointer index scale. In other respects this balance is similar to the other analytical balances made by Becker. Several other balances (Kuhlman) of approximately the same range and accuracy are also available.

MODIFIED ANALYTICAL BALANCES

To speed up analytical weighings several modified analytical balances of 200 g. capacity have been developed. In one type, the Ainsworth "Multiple Weight Carrier Balance", each weight is carried on an arm, bearing a number corresponding to the weight, from which it is transferred to a cross bar attached to the stirrup. A selector, operated from the outside of the case, transfers the weights from their rests to the stirrup for use and returns them to their rests after use. An indicator rod attached to the selector facilitates reading the total weight deposited on the stirrup. The weighing up to 1.220 g. can all be done while the balance door is

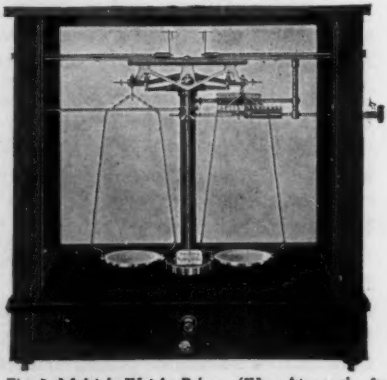


Fig. 5. Multiple Weight Balance (*Wm. Ainsworth & Sons, Inc.*)

closed, weights being added or subtracted from the pans while the balance is swinging. The final mg. and tenths mg. weighing is done with a rider on the usual beam. Weights larger than 1 g. are added to the pans as usual.

The Keyboard Balance (Also Ainsworth, see Fig. 8) is similar to the multiple weight carrier balance, but here the weights are transferred to and from the stirrup beam by a lever system actuated by typewriter-like keys at the front of the balance case. Any number of keys can be depressed at the same time, individual weights transferred back and forth at will without

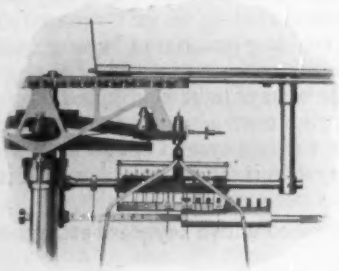


Fig. 6. Multiweight Carrier

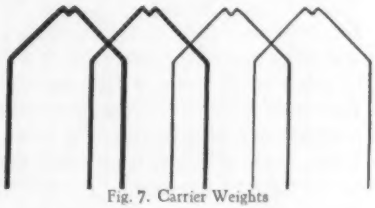


Fig. 7. Carrier Weights

Fig. 8. Keyboard Balance with Reflection Reading Device. (*Wm. Ainsworth & Sons, Inc.*)

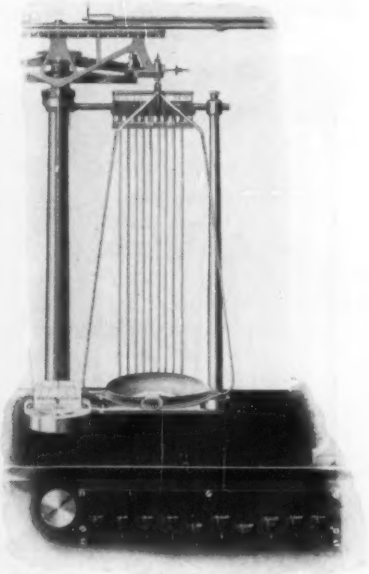


Fig. 9. Keyboard Operated Weight Carrier

disturbing other weights. All weights can be returned to the rack simultaneously by a reset key. This method of using standard units of mass for the fractional weights has the advantage of rechecking the balance against standard weights at any time. The individual fractional weights are always handled mechanically and therefore do not become bent or broken. Wear is correspondingly decreased. Weighings can be made in a fraction of the usual time. The capacity of the balance is 200 g. The mg. and tenths mg. weighings are carried out on the regular balance beam as in the ordinary analytical balance, the keyboard attachment taking care of

weights up to and including 1 g. The sensitivity of this balance is of the order of 0.01 to 0.05 mg. Its period of oscillation is 10 seconds. The Keyboard Balance is supplied with two different systems of keys. On the regular type the keys, starting at the left are numbered because of "better distribution of the weights on the beam when all weights are in use." It has been thought that after all, not all the fractional weights were in use for any long continued time and so the convenience of having the weights in their numerical order was more reasonable. This lead to the development of the "Pittsburgh" keyboard, with the weights in the following order; 10,20,30, and 50 mg., 1 g., and 500,300,200 and 100 mg. The Keyboard Balance can also be obtained with a reflection reading device for magnifying the deflection of the beam about 6 times, enabling readings to be more quickly made with less eye fatigue. The device consists of a lamp housing at the top of the balance case, from which the beam of light is projected through a condenser, slot diaphragm, lens and prism onto a mirror carried by the beam, from which it is reflected through a mirror system onto a large scale at the front of the case. The reflecting system is self contained, so that it is always aligned even after the balance has been moved.

One foreign balance (Sauter) is now supplied with a keyboard attachment for the larger weights. (Fig. 10)

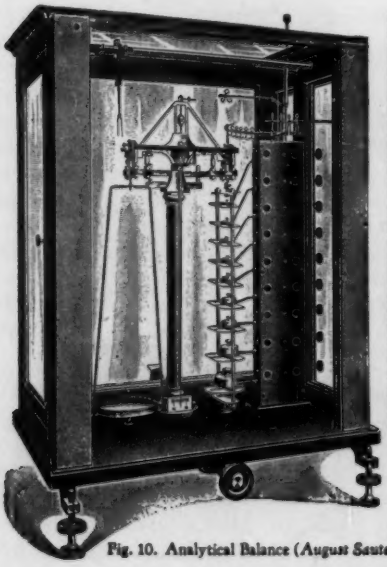


Fig. 10. Analytical Balance (*August Sauter*)

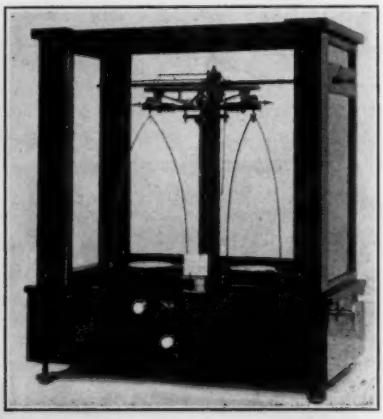


Fig. 11. Chainomatic Balance with Knotched Beam (*Christian Becker, Inc.*)

THE CHAINOMATIC BALANCE

The Chainomatic type of balance is similiar to the ordinary analytic balance except that a chain, with one end attached to the balance beam and the other attached to an elevating screw, takes the place of the usual rider and small fractional weights The weight of the chain is distributed between the beam and the elevating screw, the higher the screw the less weight carried by the beam. The screw is actuated by a hand crank at the right side of the case, the imparted motion being mechanically transmitted to the screw. The column supporting the elevating screw (see Fig. 12) has

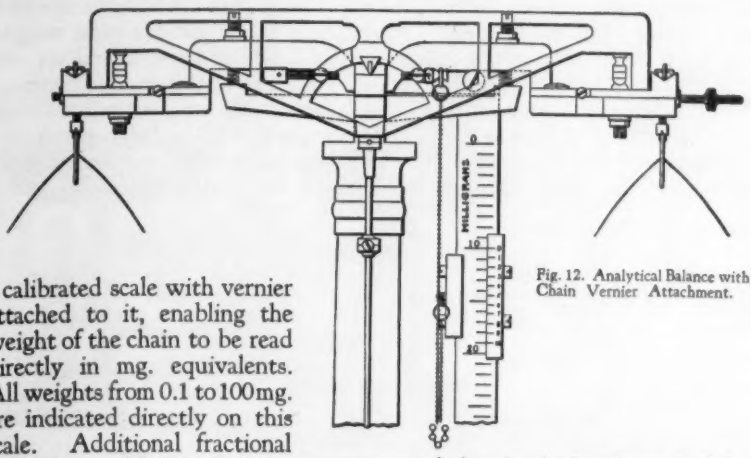


Fig. 12. Analytical Balance with Chain Vernier Attachment.

a calibrated scale with vernier attached to it, enabling the weight of the chain to be read directly in mg. equivalents. All weights from 0.1 to 100 mg. are indicated directly on this scale. Additional fractional weights are added to the balance pan as needed. As the hand crank of the balance can be operated while the beam is swinging and the case closed, much time is saved, and the weighing done quite conveniently.

This type of balance is supplied in a number of capacities for analytical purposes. Some of them are furnished with special equipment for specific gravity determinations, surface tension, etc. A few of these are equipped with the Autodex,* rapid zero setting device. The regular balance has the beam ungraduated, but in some models, the beam is graduated in 100 mg. divisions, in which case weights from 1/10 mg. to 1.1 g. are eliminated. (Fig. 11)

Rotating Weight Balances (Sauter) are similar to the Chainomatic balances in that they do not require the use of the smaller fractional weights. A pointer, or rotating weight as it is called, takes the place of the chain. The pointer has the shape of an L, with the shorter arm rotating in a bearing attached to middle of the beam. The longer arm extends toward the front of the case and is moved to the left or right, through a rod operated from the outside of the case. As the rod is slid into or withdrawn from the case, the free end of the pointer moves nearer to or further away from the center of the balance, increasing or decreasing the effective load on the beam. A calibrated scale indicates the equivalent load on the beam. This balance can also be operated while the beam is in motion. A larger balance with a pointer attachment range of 1 to 1000 mg. is also available.

THE TORSION BALANCE

The principle of the torsion balance (Torsion Balance Co.) is the substitution of steel bands, under tension, for the knife edges of the regular analytical balance. The essential parts of this balance are the 3 trusses, with the bands around their edges. The central band serves as the fulcrum while the two end bands serve to maintain the balance pans in a horizontal plane.

*The Autodex is a patented device attached to the analytical balances for rapidly resetting the zero point. In adjusting the equilibrium of a balance, the adjusting nuts at the ends of the beam are turned one way or the other, until the indicator rests at the zero point of the index plate. This necessitates the raising and lowering of the door and frequently introduces an error due to temporary increases of the beam length caused by the heat of the hand while adjusting the beam. The Autodex device is a simple mechanism attached to the regular balance. It has a thumb wheel at the side of the balance, which when turned moves the index plate to one side or the other until the index arm rests directly over the zero point of the index scale. This obviates moving the beam adjusting nuts, opening the case and recording the off-zero point. It also saves the wear on the knife edges as it eliminates the need of lifting the beam from and resetting it on the edges each time any adjustment is made. It is now available for both the Chainomatic and Becker assay balances.

The entire mechanism is virtually a single unit without moving parts which can become displaced or wear. By means of the adjustable poise weight, the center of gravity of the balance can be raised or lowered and the sensitivity of the balance varied as desired. Because of this one-piece type of construction and absence of wear, this balance, once adjusted will maintain that adjustment as long as the balance functions. These balances are very sensitive and quick acting. They may be obtained in a number of styles and sizes. Many are now supplied with the Air Dash Pot Attachment.

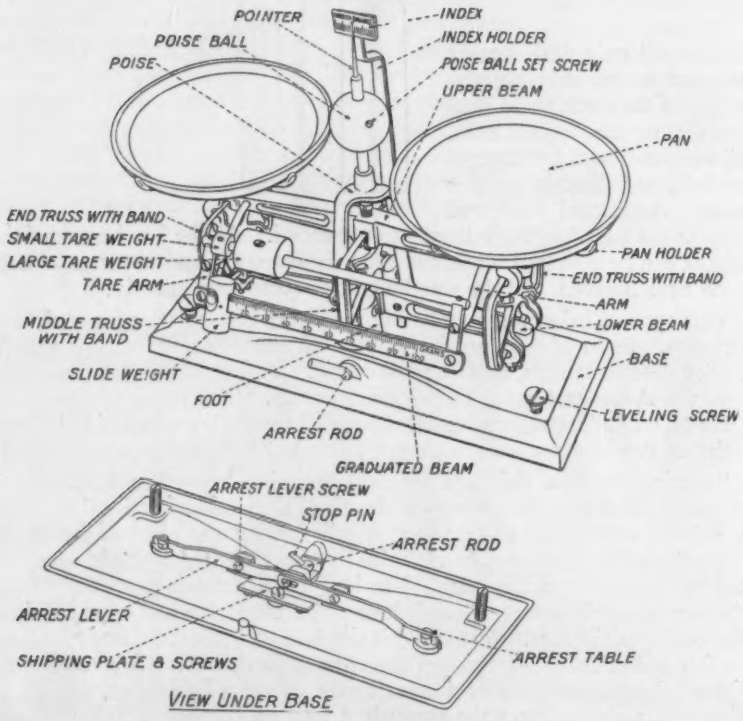


Fig. 13. Principal Parts of the Torsion Balance

The Air Dash Pot Attachment—The air dash pot damping attachment consists of a piston attached to the scale pan sliding into a compression chamber attached to the base. As the pan swings the air is compressed, the work done opposing the swing and damping the fall of the pan. A vent hole in the side of the compression chamber, serves as a control over the pressure within the chamber and so varies the degree of damping. This device speeds up the weighings on this balance without seriously affecting the accuracy and sensitivity. A number of foreign balances have this same type of damper, although applied to the analytical type of instrument. In some cases the compression is effected by two large air filled pistons attached to the bottom of the scale pans and which slide back and forth into compression chambers directly below. Others have the compression chamber mounted near the top of the balance case, with the piston attached to the top of beam.

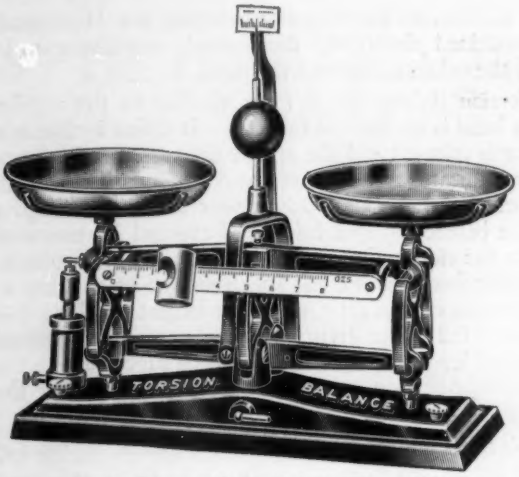


Fig. 14. Torsion Balance with Air Dash Pot (*Torsion Balance Co.*)

Air Vane Damping Attachment—This attachment operates much the same as the air dash pot attachment but has a large light weight fan or paddle attached to the beam near the top of the case. The vane "fans the air" damping the swing as it passes through the air. The attachment is used on the Roller Smith type qv. torsion balance and a number of the foreign analytical type balances. The air vane has the advantage of effecting the damping, within limits, without the possibility of mechanical wear. Its use is limited to balances where the load is very small.

Oil Damping Attachment—This is similar to the air damping attachment, but the vane swings in a bath of oil. The damping is correspondingly increased, and the period of the balance decreased. This balance has not won the favor of American chemists, due possibility to the tendency of the viscosity of the oil to change with temperature and the sensitivity and period following the viscosity. Some manufacturers have at times recommended the use of special low viscosity-low flash point oils for this purpose, but none seems to have the courage to develop and supply such an oil.

Magnetic Damping—This type of damping is employed on the Hugershoff analytical balance. A small metallic vane also attached to the balance beam, swings between the poles of a magnet, the magnetic attraction serving to dampen the swing. The capacity is 200 g. with a rated sensitivity of 0.2 mg. A permanent magnet is employed, so magnetic materials cannot be accurately weighed on this balance. An electromagnet free from residual magnetism might point the way to the solution of this problem of damping, should such a

Fig. 15. Roller Smith Torsion Balance.

magnet be found. In addition to the magnetic damping, the Hugershoff balance has a self contained electrically illuminated, magnifying scale mounted at the front of the column, between the pans.

The Roller Smith Torsion Balance for Wire is similiar to the regular torsion balance in that a band is used as the fulcrum. It differs in that it is direct reading. A lever is released and the arm at the top of the balance is rotated until a pointer indicates zero, the weight on the pan is then indicated by the position of the arm. Zero adjustment is made through a screw at the rear of the balance. This balance is checked by means of check weights, similar to the riders of the analytical balance. It is obtainable in several sizes ranging from the smallest which weighs up to 6 mg. in 0.05 mg. units with 200 units on the scale, up to the largest weighing 0 to 50 g. with 250 divisions of 0.2 g. per division. While this was designed primarily for weighing small lengths of wire the scale pans supplied with the balance and used for standardization serve admirably in converting the balance into one for general use.

The next article in this series will discuss many of the special balances of particular interest to the production man.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

HANDBUCH DER WISSENSCHAFTLICHEN UND ANGEWANDTEN PHOTOGRAPHIE. Edited by *Alfred Hay*, Volume VII. Photogrammetrie und Luftbildwesen. Edited by R. *Hugershoff*. *Julius Springer*, Vienna, 1930. Paper, 7 x 10 inches, 264 pages. Price 24 R. M.

In hardly any other field of applied science has aeronautics worked such change as in photogrammetry if under this name, is understood the problem of determining from the central projections as represented in photographic pictures, any other orthogonal projections of the same picture. This stimulating influence is best shown in the words of the author that the instruments and methods developed for special use in evaluating aerial photograms made possible the introduction of these methods in terrestrial photogrammetry so that now only one general case need be treated.

The book gives in the beginning a very interesting historical review of the gradual development of the art to determine from pictures plans and elevations of bodies, landscapes, etc., but the practical foundation of our present methods was laid by G. Hauck in 1883 when he showed that a body can be represented in any projection as soon as any two other projections are given. This fact is the basis of most of the instruments for evaluating photograms, drawing maps and plans, and developing the line contours of a locality. The author is a recognized European authority on the subject of photogrammetry who has himself contributed several apparatus and ideas, and he presents the matter in masterly clearness and simplicity starting from the historical development and explanation of the simple reproduction point by point of a picture from a survey or photograph, then from a pair of photographs, and finally explaining the methods of continuous automatic reconstruction of the object from a pair of pictures (auto-grammetry). In the following chapters, instruments and apparatus for photography and drawing are treated, how the orientation of a camera is found, and a description is given of mounting fixed and movable cameras, the latter comprising instruments used for surveying from airplanes in aero photography. With the least amount of mathematics the theory of determination of the elements of orientation is expounded, and the methods of aero triangulation for surveying from the air are discussed; these methods have all but supplanted the terrestrial methods used formerly as they offer the great advantage that the results can always be checked over again by the pictures.

A concluding chapter is devoted to the particular technique of aero-photography describing the procedure, aeroplanes used and mounting of cameras, how flights for surveying should be arranged and height, velocity and overlapping of sections determined. The numerous illustrations of instruments and descriptions of their particular details give proof of the intimate knowledge of the author with his subject.—Max Hartenheim.

The Handbook of Industrial Instruments

M. F. Béhar*

CHAPTER XI

Pressure Measuring Instruments

1. Plant Standards

Modern industrial pressure instruments of classes that require calibration by comparison—such as elastic-member gages—are so designed and constructed that intrinsic sources of error are minimized as far as possible. For actual service such gages are usually preferred to "primary" manometers by reason of their easy reading dials, recording features, etc. But as was pointed out in Chapter X, Section 4, the very features of construction that go to make a robust yet sensitive typical industrial instrument are usually those that preclude its being calibrated by itself without reference to another pressure measuring instrument. There is no getting around the obvious fact, for example, that if the hand or pen arm of a gage is loosened, it cannot be replaced without subjecting the gage to a known pressure (which may simply be zero differential with the atmosphere acting equally on the inside and outside of the spring. This is merely "re-setting" and is far from actual calibration, the procedure of which will be discussed below.) It also is obvious that the desirable property of "ease of reading" may often be attained only by a very large multiplication of the motion of the flexible element. For such and many other reasons, including the imperfection of any manufactured product (and the reader knows that there are many "grades" of gages) it is necessary to calibrate all gages frequently. The frequency is a matter of judgment and experience, and will not be discussed by the author. The *necessity* of calibration, however, cannot be emphasized too strongly. Even such a "primary" measuring instrument as a mercurial barometer, although it may be used as a reference standard for calibrating other barometers in a plant, must itself be calibrated, as was pointed out in Section 6 of the preceding chapter. Therefore, before taking up one by one in a descriptive way the various classes and types of industrial pressure measuring instruments, we shall first take up one "group" of instruments, comprising instruments belonging to various classes but all having a common purpose—to serve as Plant Standards.

The designation "Plant Standards" is adopted for convenience and for want of an "official" name for such devices. It not only covers gage testing outfits and gage calibration apparatus but especially those pressure measuring instruments which are designed to serve as accessible reference standards. There are no tangible international or national "primary standards" for pressure, analogous to the well-known material standards of length and mass in the custody of our Bureau of Standards and of similar institutions abroad. Extreme precision pressure instruments—wherever they may be—which are used for reference, are all "secondary standards" only in that sense.

*Engineering Editor.

The word "secondary" being therefore ambiguous as applied to instruments of the "primary" class, and being otherwise objectionable, cannot be employed. The ideas of accessibility or "purchaseability" and of industrial service are well conveyed, it is believed, by "Plant." It is of course recognized that a portable testing outfit can render excellent service in the field, as in the natural gas and petroleum industries, without seeing the inside of a plant for months at a time.

Judgment and experience must dictate the selection of plant standards, from the simpler forms offered by several manufacturers to the more elaborate forms which embody the utmost refinements of the state of the art in 1931. "Grades" do not seem to exist here as they do in gages: the author can safely set it down as true that the plant standards of American manufacture are all of good design and excellent workmanship.

Among the plant standards are instruments which can either be used for calibrating gages, or themselves serve as gages when utmost accuracy is required beyond all doubt. Such instruments are Dead Weight Gages and Fluid Pressure Scales. It is important to note that even slightly fluctuating exterior pressures cannot be measured directly by such instruments. Their principal use therefore is to test, check and calibrate gages. This function is made possible by provisions for building up interior pressure within the system of the instrument, and holding definite pressures within very narrow limits.

For pressures below atmospheric, liquid columns may serve as plant standards if precautions advocated in Chapter X, Sections 5 and 6, are carefully observed, and if other precautions are taken to insure correct calibration when such liquid columns are used for calibrating vacuum gages. One example will be given below of a typical arrangement for producing a vacuum, holding it within narrow limits and measuring it by a mercury column in order to calibrate a vacuum gage.

(a) Test Pumps

One essential is a pump for creating the pressure applied simultaneously to the gage under test and to the standard. There are on the market several forms especially made for this purpose. In general they consist of a cylinder down which a plunger is forced by a threaded piston rod ending in a handwheel; together with pipe connections, etc., all assembled on a suitable base. None is illustrated, but the general plan is shown by the portable pump in Fig. 231, which portable form, as a matter of fact, can also be obtained separately.

(b) Testing Outfits with Precision Comparison Gages

These well-known outfits consist essentially of a pump to be connected to the gage under test and to a high grade master or "inspector's" gage. These, with various accessories, are generally put up in a carrying case, as shown in Fig. 231. It goes without saying that the value of such testing apparatus depends mostly on two factors: (1) the quality of the reference gage—its initial accuracy and especially its permanence of calibration; and (2) the personal equation—each outfit being generally assigned to one man (often *owned* by him). The reference gages should be calibrated with the utmost possible care against dead-weight gages of the highest sensitivity and accuracy.

(c) Liquid Column Gage Testers

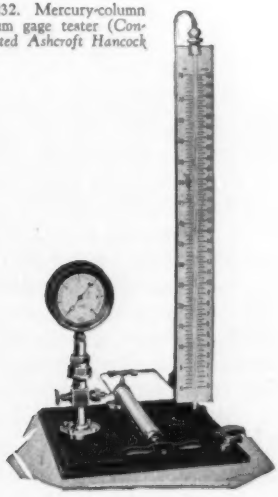
Direct comparison with a known liquid head is the principle utilized in these testers, the general plan of which is shown in Fig. 232. Liquid columns can be used to produce a known "gage pressure" above atmospheric, or a known negative pressure or vacuum. The latter purpose is the principal one and outfits for vacuum gage checking and calibration, as illustrated in Fig. 232, are found in greater number and variety than those for gage pressures lower than those within the range of dead weight testers.

In the case of vacuum gage testers the transmitting medium is rarefied air, so that it makes no difference at what level the center of the gage under test may be. In the case of low pressure gage testers the head is the difference of the two levels of the mercury (or of the water in the infrequent cases where water is used). Therefore it is important to exclude liquid between the lower level and the gage under test, and to transmit the differential by the medium of air.

Atmospheric pressure is not a factor: it acts equally on the open liquid surface and on the outside of the elastic member of the low pressure or vacuum gage under test.

Fig. 231. "Inspector's Gage Testing Outfit" consisting of pump, standardized gage and accessories. (*Consolidated Ashcroft Hancock Co.*)

Fig. 232. Mercury-column vacuum gage tester (*Consolidated Ashcroft Hancock Co.*



Mercury should be of the highest purity; and water either air-free or of known density. Scales and reference points should be accurate and should be handled carefully when adjustments are necessary. Zero level adjustment is provided in the cistern types. For very accurate work, always make at least some of the corrections advocated in Chapter X, Sections 5 and 6.

(d) Dead Weight Gage Testers

The principle of the dead weight gage tester is the same as that of a balance: Gravity, acting on calibrated weights, provides the known force. This force being exerted on a known area, a known pressure exists throughout the fluid contained in the system (a suitable oil—see below) and if it is applied to a gage, the gage can be calibrated. This principle is illustrated in Fig. 233 which shows its essential simplicity. Extreme accuracy is possible but requires several factors for its attainment, among them the following:

1. *Known Piston and Cylinder Diameters.* The effective area is generally determined from the diameter of the oil film at its mid-thickness, half way between the piston and the cylinder. The thickness of the oil film does not

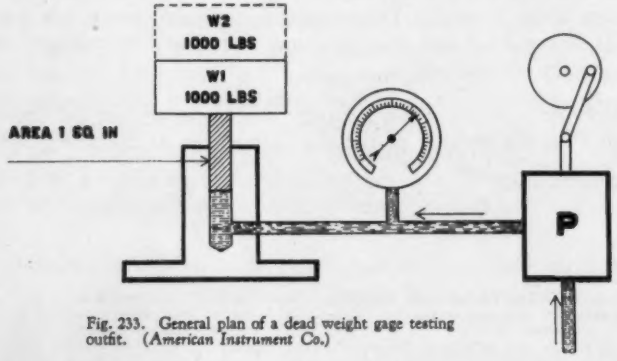


Fig. 233. General plan of a dead weight gage testing outfit. (*American Instrument Co.*)

exceed 0.0005 inch as a rule, but in the case of a new gage tester this thickness, representing the fit between cylinder and piston, is less important than the exactness of the diameters. In other words, if *both* the cylinder and the piston of a tester with a certain nominal diameter giving an area stated as a round fractional number are oversize or undersize, the satisfactory feel of a beautiful sliding fit will be altogether misleading. The nominal area is generally a small fraction of one square inch—a fifth, eighth or tenth —especially for high-pressure testers, in order to make the calibrated weights correspondingly smaller and for other practical reasons. The piston and cylinder are generally made of the same metal in order to prevent differential thermal expansion. Sometimes both are machined from the one bar of alloy stock.

2. *Known Weights.* The weights supplied are of course carefully standardized, but in how many plants are "chunks of metal" handled with care by all concerned? Inevitable result: loss of calibration. Weights should therefore be calibrated before making any important series of gage calibrations. For each order of weights in a series, a suitable balance should be used, and the maximum permissible errors for various weights should be as narrow as those given in regulations or manuals for Sealers of Weights and Measures, etc. Example, for a weight of 2267.96 grams, equivalent to a pressure of 40 lb. per sq. in. on an effective area of $\frac{1}{8}$ sq. in., the maximum permissible error is 0.40 grams. This question of weight calibration depends largely, of course, on the state of the other parts of the plant standard outfit: if the cylinder and piston are worn, the outfit cannot be used for important calibrations.

3. *Gravity Corrections.* Variations in the earth's gravitational pull, due to difference in latitude and elevation, affect the pressure exerted by the various weights, including piston-and-platform assembly or other unloaded moving parts. If, therefore, the weights are standardized before being shipped to the locality where the tester is to be operated, a gravity correction may be necessary. For values, see Chapter X, Section 5, Table XIV (which gives the values in terms of mercury columns but can be used to tell at a glance whether the differential gravity error is to be considered). The best procedure is to calibrate the weights against standardized weights at the locality itself or nearby.

4. *Buoyancy.* Each of the weights displaces its volume of air. The weight of the displaced air varies inversely as barometric pressure. While this effect is allowed for in precise research work involving heads of liquids other than mercury, it is absolutely negligible for engineering work with the metal weights of dead weight gage testers.

5. *Absence of Friction.* In the simpler testers, in which the weights are placed directly above the piston, there is only one pair of rubbing surfaces when the piston is in mid-position, and the oil film is interposed between them. In all types, rotating or oscillating the piston eliminates almost entirely the friction *effects*, while the friction *errors* of calibration are eliminated by the prescribed methods of gage calibration which involve taking "ascending and descending" readings. In the more elaborate types of testers, while bearings are provided at various points, careful operation makes them unnecessary by avoiding actual contacts. Friction errors in the gages under test are not considered here.

6. *Head of Transmitting Fluid.* Negligible in medium- and high-pressure work, because in most gage testers the difference of level between the piston and the surface of the oil below the gage is too small to count. In low-pressure calibrations, however, such a liquid head would have an appreciable effect. For that reason, dead weight gage testers of low ranges are so designed that the surfaces can be evened up, and users need only verify that this is the case. Maker's instructions tell how.

7. *Method of Operation.* Good results in calibrating gages—apart from following calibration procedures such as prescribed below—depend also to some extent on correct operation of the dead weight tester. The most important thing is to keep the piston floating in mid-position, and either spinning or oscillating. In some models, an automatic arrangement spins or oscillates the piston, but the floating is entirely up to the operator. Each manufacturer furnishes directions covering this and other details of use, which should be followed carefully. With a dead weight gage in good condition an absolutely exact pressure can be held for an hour or more by a careful operator.

Slight wear of piston and cylinder causes oil to leak early in the service life of a dead weight gage, but without appreciable loss of accuracy. Large oil reservoirs feature some models, in order to avoid necessity of refilling at awkward times as during the course of a test. Wear is not considered excessive if the following test* is satisfied:

Plug tightly the opening to the oil reservoir when the piston is in the top position, and loaded to 200 lb. per sq. in. The piston is then spun by hand,

* Based on suggestion by Dr. Sanford Moss who for a quarter century has investigated pressure measurement problems at the Thomson Research Laboratory of the General Electric Company.

by automatic means provided, or by a compressed air jet impinging on the weight while it slowly descends, due to leakage only between piston and cylinder. The time for descent of ½ inch shall not be less than 3 minutes. If the time is less, the cylinder (and perhaps piston) should be scrapped, or the tester should be labeled plainly, "Not to be Used for Class A Calibrations," or otherwise relegated to service other than that of Plant Standard.

Various forms of dead weight gage testers on the market meet practically all industrial requirements. Fig. 234 shows the cross-section of one model, and Figs. 235 and 236 afford an interesting contrast between a simple form of tester which is designed for pressures up to 1000 lb. per sq. in., and the newest and most elaborate instrument on the market made in sizes up to 50,000 lb. per sq. in.

The following matter, copied from the maker's catalog, not only covers Fig. 234 in particular, but to a large extent supplies interesting information concerning all testers of similar form:

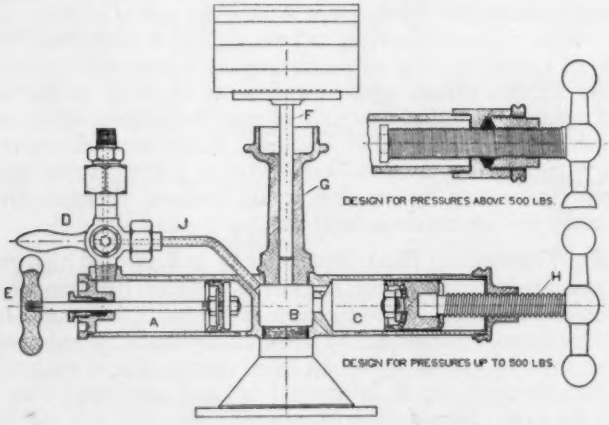


Fig. 234. Cross-section of a dead weight gage tester. (*Consolidated Ashcroft Hancock Co.*)

The tester should be filled with glycerine or light mineral oil (preferably Nujol). All oil chambers are filled through cylinder G by first removing weight plunger and platform F. Before pouring in the oil pull out plunger E and screw in H. Then turn cock handle D to the right. Pour in the glycerine or oil and fill chamber A by pushing in plunger E. This draws oil by suction from chamber B through pipe J to chamber A. Keep pouring the oil until chambers B and C are also filled. In pouring, slowly unscrew plunger H, which facilitates filling chamber C.

Connect gage with suitable connection that is furnished with gage tester, above cock D, turn handle of cock down, that is, at right angles, to supply pump A. Pull out handle E until gage shows pressure, and tube is filled, then turn handle of cock D to the left, which connects gage with chamber B. Add weights on piston F until desired pressures are reached.

Keep in mind that for testers up to 500 lb., the piston and weight platform counts as the first 5 lb. of weight, i.e., if two 10 lb. weights are placed on the platform, the gage, if correct, should show 25 lb. For testers with capacity above 500 lb., a smaller piston F is used, and weight platform counts for 10 lb. The weight platform should be kept about 2″ above cylinder G. This is done by screwing in plunger H, which displaces oil from cylinder C. Weights and piston must be kept revolving by hand while making test. Before disconnecting the gage, screw out on handle H, releasing pressure, and remove weights, turn hand of cock D down, push in slightly on handle piston E sufficiently to draw or drain oil from gage tube and connections into chamber A.

Fig. 235. Small and compact form of dead weight gage tester. (*Crosby Steam Gage and Valve Co.*)

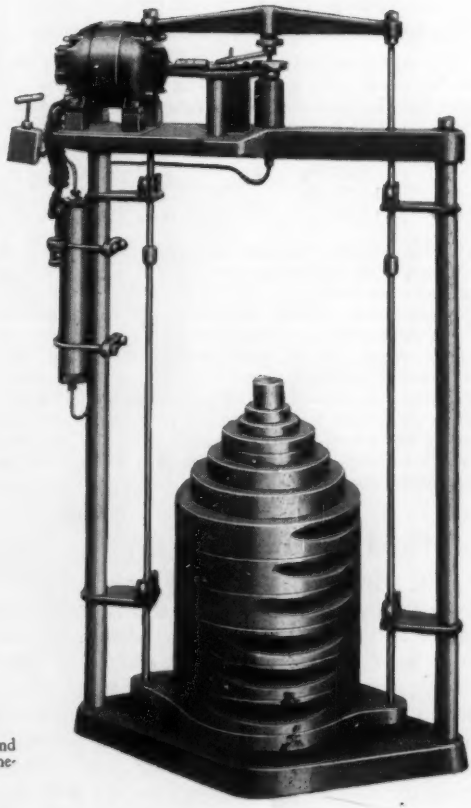


Fig. 236. High-pressure dead weight gage and gage tester embodying a number of refinements. (*American Instrument Co.*)

FORMS OF DEAD WEIGHT PLANT STANDARD PRESSURE INSTRUMENTS

The "Superpressure" dead weight gage illustrated in Fig. 236 probably represents the acme, in "stock" instruments on the market, of combining the ability to measure high pressures with the minimization of sources of error. We quote from the maker's description:

The weights of this gage are standardized by the U. S. Bureau of Standards and the diameter of the piston is checked by the same institution to 0.00001 in. The larger weights are provided with finger grips to facilitate handling. The weights are so disposed as to bring the center of gravity as low as possible. They are virtually hung from the top of the gage piston through the saddle with a self-aligning ball thrust bearing between the two, to insure that the center of gravity of the mass is exactly in the axis of the piston. There is no eccentric loading, hence the tendency to stick, due to side friction, is practically eliminated. The piston is oscillated by a motor driving a worm reducing gear to which is attached a sliding block linkage. Twice in each revolution the piston is entirely freed from this driving mechanism and is therefore free to assume a higher or lower position depending on whether the pressure has increased or decreased since the end of the last oscillation. The piston is supported above and below by ball thrust bearings to insure no damage to the gage if a heavy pressure is applied with no weights on the scale pan, or if conversely the scale pan is fully loaded with no pressure on the gage. A stop limits the upward motion of the gage in case of excess pressure, so that no damage can be done from this cause. The gage is provided with an oil reservoir to transmit the system pressure hydraulically to the under side of the piston.

In answer to questions put by the author, the maker has supplemented the above with additional information, from which the following is quoted:

The gage is regularly made in three standard sizes viz. 5000, 10,000 and 15,000 lb. per sq. in., but can be made up to 50,000 lb. per sq. in. Due to the weight of the unloaded moving parts there is a minimum possible range with each gage as follows:

Size	*Minimum possible range*	*Weight increments*
5,000 lb.	350 lb.	1 lb.
10,000 lb.	600 lb.	10 lb.
15,000 lb.	1000 lb.	25 lb.

The side rods which connect the weight platform with the upper cross member run in ball bearings. Enough clearance is allowed between the bearing and rod so that there is no contact between them unless the whole moving mass is subject to torsion due to the oscillating movement of the piston. As a matter of fact, the whole moving mass actually moves up and down without contact between these rods and bearings, therefore, the only friction is between the piston and cylinder, but these two parts are made of the same material so that the relative coefficient of expansion is zero, and due to the oil film and the continual oscillating motion of the piston, the friction is a negligible quantity. This statement is borne out by the fact that when the system is in balance (that is when the pressure under the piston equals the load on the top) a load of only one ounce additional has been known to cause the whole moving system to drop, though of course such an extraordinary degree of sensitivity is neither guaranteed nor expected.

(e) Fluid Pressure Scales

The principle here is similar to that of the dead weight gage. Pressure is built up by a screw plunger and is transmitted hydraulically to the gage under test and to the moving piston. This piston, however, actuates a *scale beam*. Hence the name, and hence also the advisability of omitting details of construction of the scale parts, which belong in later chapters on scale design and construction. An undoubted advantage of small size fluid pressure scales, such as the one shown in Fig. 237, for example, is a comparative advantage over the dead weight type: We may therefore yield the floor to the manufacturer (of *both* types):

For pressure above 300 lb. per sq. in., the usual form of dead weight tester, owing to the height of the stack of weights involved, is cumbersome, top heavy and easy to upset if not screwed down on a bench. The weights must be changed for every pressure, involving the possibility of error in count. Weights are not infrequently dropped, which damages them

FORMS OF FLUID PRESSURE SCALES

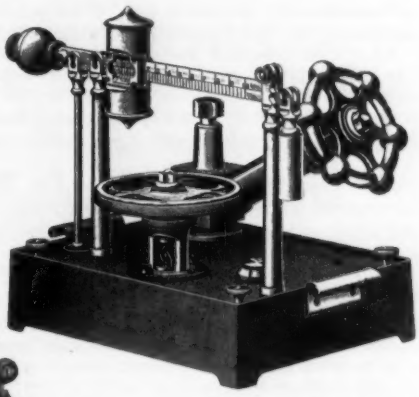


Fig. 237. Small and compact form of fluid pressure scale. (*Crosby Steam Gage and Valve Co.*)

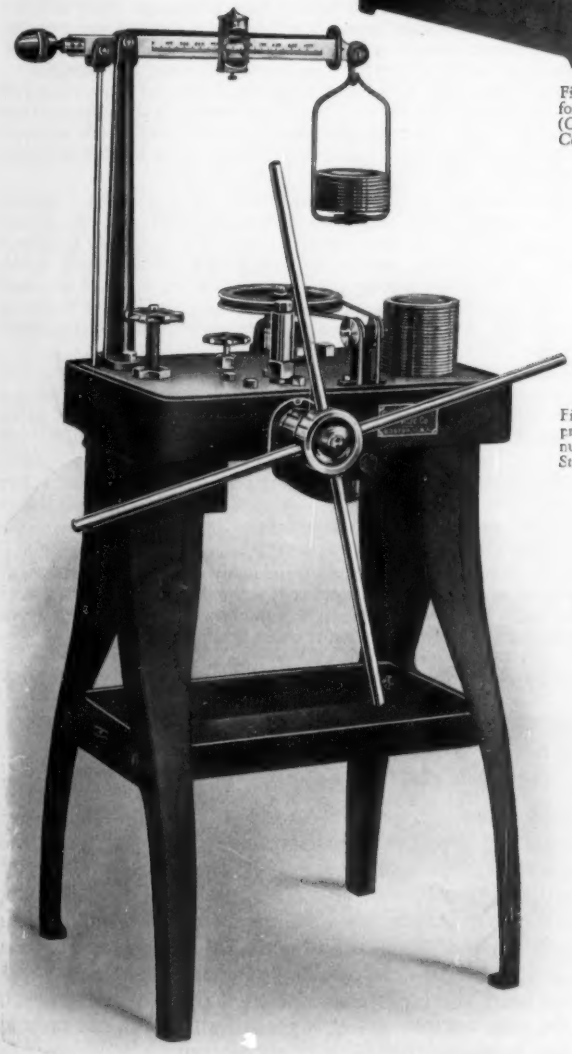


Fig. 238. High pressure fluid pressure scale embodying a number of refinements. (*Crosby Steam Gage and Valve Co.*)

and sometimes the operator as well. If the weights are bruised or injured in any way, the alignment of the stack is impaired, producing an appreciable side thrust on the piston.

All of these difficulties are avoided in the Crosby Fluid Pressure Scale for pressure from 0 to 3000 lb. per sq. in. In this instrument, which weighs less than the gage tester and is contained in a single mahogany carrying case, the use of heavy weights is avoided and the pressure is read directly from a graduated scale beam. The instrument is compact, simple in design, easier and quicker to operate than a dead weight tester.

What the instrument shown in Fig. 236 is to the dead weight type, the instrument shown in Fig. 238 is to the scale type: it probably represents the acme at the present time. Concerning this model the maker states the following:

This instrument has a capacity for measuring and testing fluid pressures from 0 to 25,000 lb. per sq. in., reading by vernier to one-pound graduations the fluid pressure being weighed and indicated directly upon the balance scale beam. It will be found accurate and sensitive at all pressures from the very lowest to the very highest within its capacity. The errors due to friction, temperature, and barometric conditions have been so minimized or eliminated by the counter-balancing of such effects that no table of corrections or special manipulation of results is required in connection with its operation. This Fluid Pressure Scale is intended for testing and calibrating pressure gages and other high pressure apparatus, and it will be found equally useful for measuring the pressure applied in determining the safe or bursting strength of any hollow body or receptacle.

Any pressure gage to be calibrated or apparatus or article to be tested is attached directly to the cylinder of the pump which forms a part of the instrument, and pressure is applied upon the body of oil contained within it by means of the screw plunger accurately fitted and designed for this purpose. The resulting pressure upon the fluid is communicated to the interior of the working mechanism of the gage or of the apparatus or article under test, and at the same time to the weighing cylinder of the pressure scale which contains the piston to communicate the pressures to the scale beam. Accurately standardized dead weights afford direct measure of the pressures.

To eliminate the possibility of error due to friction or capillary action of the fluid, it is necessary that the weighing piston be revolved slowly at a uniform speed, free from sudden variations or vibrations, and for this purpose the instrument is fitted with a self-contained electric motor to rotate the balance wheel attached to this piston at about 100 revolutions per minute.

The operation of this Fluid Pressure Scale requires no special technical skill or training, but strict compliance with every detail of the instructions is required, and an intelligent understanding of the purpose of the instrument and of the proper care required in obtaining accurate results from any scientific apparatus of this class is essential.

. . . The instrument is so adjusted as to give a sudden and easily determined movement of the scale beam at the moment when the desired pressure is secured, as preferable to a more gradual movement which might be maintained longer in equilibrium, but would not afford sufficient accuracy in determining sharply the critical pressure desired.

(Continued from Page 2)

In engineering practice as distinguished from scientific research, however, measurements are usually made for the purpose of controlling the measured conditions. This practical attitude, too, was in evidence at the A.S.M.E. meeting. The annual Progress Report of the Iron and Steel Division, for example, included so many comments on controlling instruments and devices for blast furnaces, open hearth furnaces, etc., that the committee which drew it up would seem to have concluded unanimously that instrument control developments were the biggest thing that happened in their field in 1930 . . . which we may venture to say is probably the case not only in ferrous metallurgy but in many other fields of engineering!

NEW INSTRUMENTS

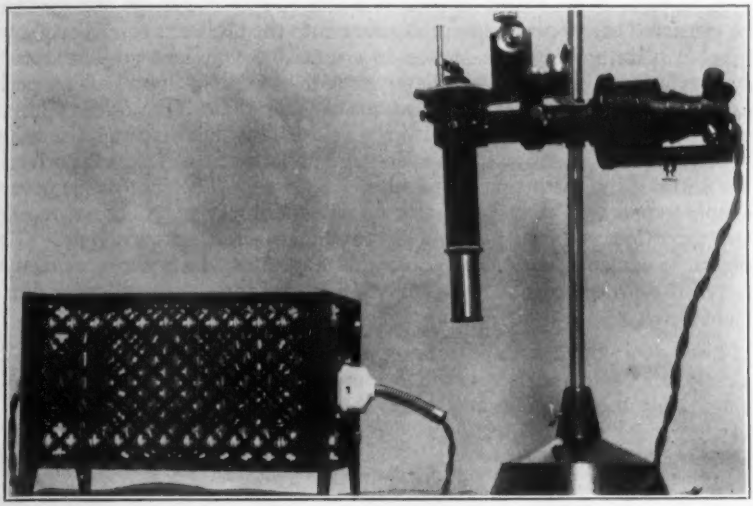
Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional Information.

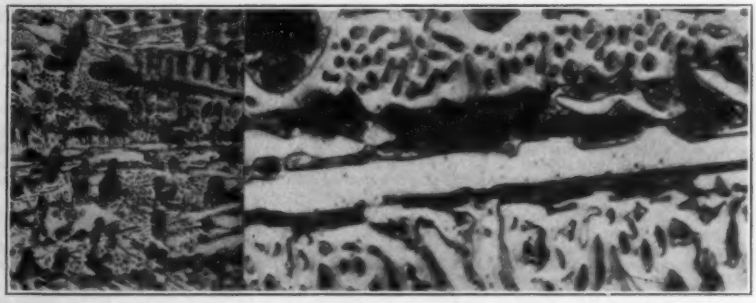
"Opacus" Metal Microscope

(Clay-Adams Co.)

THE construction of this microscope is based on the Le Chatelier principle. It combines the principle of the inverted metallurgical microscope with the ease and convenience in handling of the usual type without in any way affecting the optical advantages of the former.



Its optical features are the same which are found on large metallographic benches with the exception that the totally reflecting prism used for visual examination is fixed so that the same ocular serves for both examination and photography. To accomplish this the illuminating system and the micros-



Magnification 100X Magnification 2000X

Sample of Cast Iron (Both Micrographs reduced to ½ original)

MAGNIFICATION TABLE

Projection Distance	25 cm.			50 cm.			1 Meter			2 Meters		
	Ocular			Ocular			Ocular			Ocular		
Objective	1 (5 x)	2 (7 x)	30 (10 x)	1	2	3	1	2	3	1	2	3
MA	40	50	75	80	100	150	160	200	300	320	400	600
MB	65	80	15	130	160	230	260	320	460	520	640	920
MC	85	105	150	170	210	300	340	420	600	680	840	1200
MD	195	245	350	390	490	700	780	980	1400	1560	1960	2800

cope itself, which are connected in one rigid body, are made to rotate in the vertical plane so that after location of a desired spot the image obtained can be projected in any given direction either onto the table or a screen or photographic plate. The light source is a special 6 volt lamp. The optical system is good, both in resolving power and strength of light. A properly exposed negative at 2000 magnifications calls for about 30 seconds exposure time. Projected on a screen until the field is four feet diameter the image is perfectly bright and, what is even more important, the image is perfectly flat without any distortion at the edges whatever. The microscope is very simple to operate. Once adjusted the illuminating system does not require any attention and final focusing is reduced to a few seconds time. The objective remains stationary while the stage, to which the specimen is fastened with a spring clamp, is moved both by the coarse and fine adjustment screws.

Used as a projection apparatus it is possible for one or more persons to clearly and conveniently examine samples projected on a table or wall, eliminating the eyestrain and disadvantage of individual examination.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

THE USE OF THE MICROSCOPE. *John Belling.* McGraw Hill Book Co., New York, 1930. Cloth, 6 x 9 inches, 315 pages. Price $4.00.

The first 15 chapters, about half of the book, deal quite thoroughly, with the various essential parts of the microscope. The chapters on the Testing and Care of the Microscope are also very well done. These chapters alone make the book one to find a place on the shelves of anyone interested in a microscope. The bibliography and glossary round out the work and contain, along with the chapters mentioned above, much valuable information not elsewhere readily available.

In some respects the rest of the book does not equal the first part in quality and arrangement. The chapter on Microscopic Outfits might be placed to advantage after the one on photography. The historical and more philosophical sections might be carried over to the introduction, while the one on Objects of Biological interest might make a convenient appendix. The "Fifty Practical Exercises with the Microscope" listing should generate a demand for the book in schools giving courses in microscopy.

It is unfortunate that the author has given so little information on the newer chemical, petrographical and metallurgical microscopes and the newer extremely high power magnification and photographic technic which is playing so important a part in modern industrial applications of the microscope. While there are some weaker spots in the book, it is on the whole very well done and has much to recommend it. Arthur Schroder.

Relays for Use with Light Sensitive Cells

(Weston Electrical Instrument Corp.)

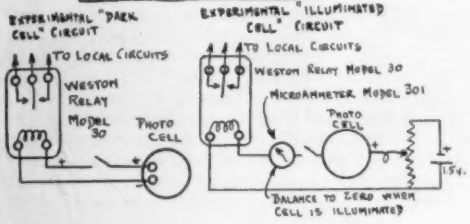
THE possibilities of putting light sensitive apparatus to work in both the industrial and experimental fields have as yet barely been sensed. Only when the action of the light sensitive cell has become common knowledge to the pioneer of industry—the Experimenter—can we hope for any great commercial usage of this relatively modern instrument of science.

However, the photo-electric cell, which transforms light energy to electrical energy, serves comparatively few uses by itself—in the majority of cases it will be desired to carry the transformation still farther—to transform the electrical energy to mechanical energy so that the movement of some particular piece of apparatus can be accomplished.

There are many methods by which a mechanical operation can be started by minute electrical impulses—the most commonly used methods involve the use of a sensitive relay.

Having this in mind several suitable relays have been prepared for photo-electric experimental work and for photo-electric automatic operation and control in the industries. A few typical applications are shown below.

FOR EXPERIMENTAL PURPOSES

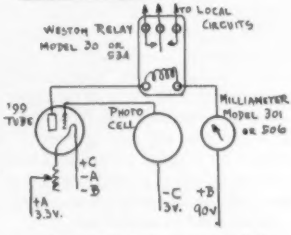


This circuit should be used when cell is normally "dark" and the "illuminated" period is in the magnitude of a few seconds.

This circuit should be used when the cell is normally "illuminated" and the "dark" period is in the magnitude of a few seconds.

Note: When these circuits are in operation a small amount of current passes through the photo-electric cell—this materially shortens the useful life of the cell. Therefore, the circuit should be closed only when experiments are being conducted.

FOR INDUSTRIAL USE



Above circuit is recommended when the photo-electric cell is "dark" or "illuminated" to any degree and the outfit is to operate continuously without much care or attention.

The use of this circuit causes no drain of current from the photo-electric cell and, therefore, its useful life is greatly prolonged.

For Experimental Purposes—A Model 30 Relay which is adjustable over a range of 40 microamps—that is—by means of the contact screws the relay can be adjusted so that it will open or close a local circuit with any value of current from 10 to 50 microamps. passing through the coil.

For Industrial Use (Relay Operated by Plate Current of Vacuum Tube)—A Model 30 Relay adjusted so that under normal conditions—that is—with 3 MA. plate current—the contact arm stands midway between the contacts and when the illumination on the photo-electric cell is changed sufficiently the contact arm moves over against a contact and thus closes a local circuit. This relay is adjustable, by means of the contact screws, over a range of from 3 MA. ± 20 microamps. to 3 MA. ± 80 microamps.

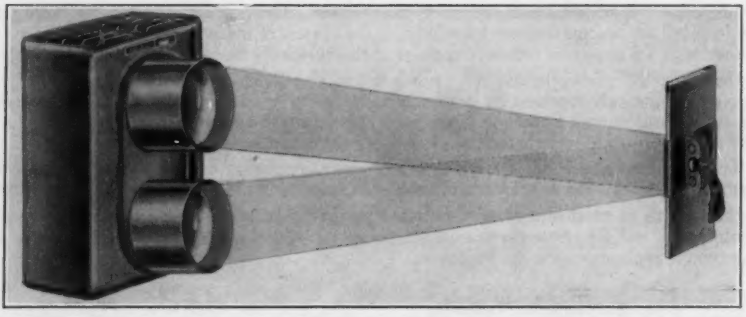
A few of the applications in which Weston Relays can be used are listed below:

Automatic Control	*Automatic Inspection*	*Automatic Operation*
Temperatures	Vacuum Tubes	Burglar Alarms
Chemical Processes	Incandescent Lamps	Fire Alarms
Water Levels	Dry Cells	Gas Detectors
Speeds	Resistors	Smoke Detectors
Voltages	Of Color	Counting Devices
Currents	Of Size	Photo-electric Devices
		Doors

Photoelectric Relay

(G-M Laboratories, Inc.)

THE illustration shows a recently developed compact photoelectric relay and light source (G-M type No. 1281) for application to many industrial and commercial operations. This device is essentially an electric switch controlled by means of a beam of light. Any interruption of this beam of light operates the switch and will thereby operate or control electrical devices.



The application of this unit is meeting with wide acceptance among industrial and commercial organizations for counting parts on conveyors, inspecting work on presses, operating safety devices, controlling the timing of operations, turning machines on and off, and numerous other operations which can be done more accurately and at much lower cost than by human labor. The use of photoelectric cells will save industry immense sums annually.

In operation the light from the upper lens is reflected from the remotely placed mirror to the lower lens, where it is received by the photoelectric cell. Any interruption of this beam of light by a piece part, metal stamping, finished product or other object causes the relay contacts to close, thereby operating a counter, power switch, signal or other device. The advantage of this arrangement is the frictionless interruption of the light beam by the object to be counted or controlled.

The Visitron photoelectric cell, single stage amplifier, light source and other essential parts are completely enclosed in a drawn steel case. This arrangement greatly simplifies the installation of the unit, since in this form it is only necessary to connect to a 110 volt—60 cycle line. Accessory equipment in the form of magnetic counters, power switches, etc., have been developed to operate directly from the photoelectric relay.

New Push Button Master Station

(Monitor Controller Co.)

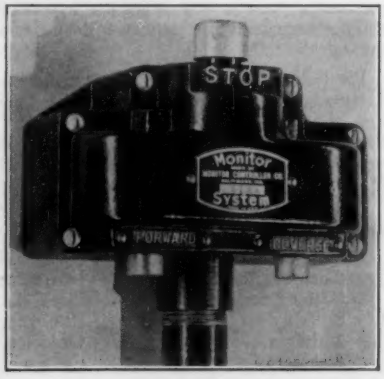
THE new ironclad push button master station is available for use in either a. c. or d. c. circuits, this station provides forward and reverse mometary contact control, and is particularly suited to machine service.

This reversing station is constructed with massive yet flexible contacts and insulation mechanically and electrically strong.

A safety and convenience feature results from the arrangement of the buttons . . . the forward and reverse buttons being in a protected position at the bottom and the stop button on top where it is protected and extremely easy to operate. This arrangement is also excellently adapted to give quick-action inching in either direction.

The fixed contacts and wiring are carried in the base, the push buttons in the cover.

This simplicity of design results in positive contact and general compactness of the switch.



New CO_2 Indicator and Recorder

(Permutit Company)

THE new model Ranarex CO_2 indicator and recorder retains established Ranarex principle, based on specific gravity, but the design has been simplified, and the machine made more compact and rugged.

All working parts are easily accessible. The entire indicating and recording mechanism is attached to one plate, and the driving mechanism, including the motor, to another. Both plates may be removed without the use of tools, by loosening a few wing screws; their removal opens all gas passages over their entire length. Connection between the humidifier compartments and the measuring chambers is established by channels of ample cross section.

Fig. 1. Ranarex CO_2 Indicator and Recorder—Wall Type.

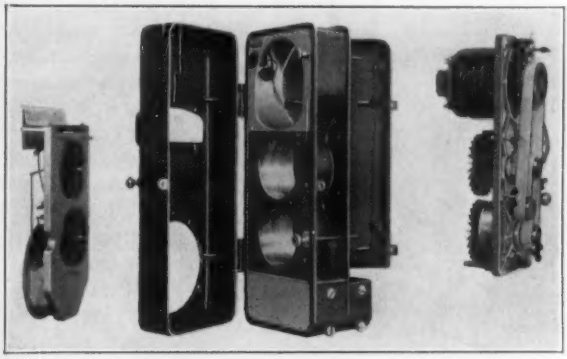


Fig. 2. Ranarex Opened for Inspection. Left, plate with indicating and recording mechanism; center, dust-proof aluminum casing; right, plate with driving mechanism.

In most instances the time lag will be less than a minute. This is of great importance to the power plant engineer and his assistants, as it enables them to correct firing conditions just as soon as a change is needed. Hence the proper percentage of CO_2 can be maintained at all times.

Corrosion resistant materials such as bakelite and special alloy steels are used extensively for parts in contact with flue gas. The machine is enclosed in a dust-proof cast aluminum casing and is not affected by heat, moisture or shock. It is available for wall or panel mounting.

The standard 9″ scale and circular chart 8″ in diameter are graduated from 0 to 20% CO_2, and accuracy within 0.3% CO_2 is guaranteed. Scales from 0 to 30% CO_2 for blast furnace gas and 0 to 40% CO_2 for lime kilns are also available. The recording mechanism is driven interchangeably by a spring clock or an electric clock, as desired.

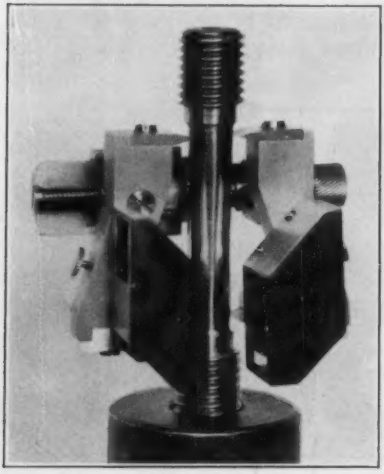
Ranarex specific gravity recorders, with circular chart and of substantially the same construction as the CO_2 recorders described above, have been developed. The standard scale range extends from 0.2 to 1.0 (air = 1), but special ranges can be supplied upon request.

A special Ranarex recorder for the control of butane-air mixing has been developed. This machine has a specific gravity range from 1.0 to 1.2 with a superimposed adjustable scale graduated in B. t. u. / cu. ft.

New Mirror Extensometer

(*Riehle Bros.*)

THIS mirror type extensometer is adaptable to routine testing up to 1-inch tension test specimens of 2-inch gage length, where a high degree of precision in proportional limit or modulus of elasticity determinations is desired. By use of a system of four prisms, two ends are gained: (1) elongation on both sides of the specimen are automatically averaged, and (2) any movement or vibration of the specimen is automatically cared for, so that readings are unaffected.



Optically, the instrument consists of a telescope with horizontal cross-hair supported on a bracket, a system of four prism mirrors on a light weight extensometer attached to the test specimen and an illuminated scale supported at a fixed distance from the test specimen on the opposite end of the bracket from the telescope. The upper two prisms are fixed in position during the test. The lower prisms are so supported that they tilt as the test bar elongates.

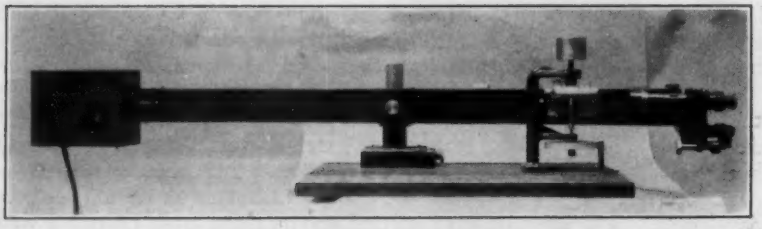
By use of a "crossed spring" support, it becomes possible to attach the movable prisms permanently to the main body of the extensometer, eliminating need for the separate Martens lozenges, and so making the extensometer, as a whole, much simpler to handle.

Readings may be taken directly to 1 part in 100,000 on a 2-inch gage length and be estimated to a fraction of that figure.

Placing the Instrument on the Specimen—The prism set screws should be screwed in as far as the stops will permit. This sets the knife edges 2 inches apart. By turning clamping screw separate the instrument until knife edges clear the specimen, then reverse motion until the knife edges hold lightly on the specimen. Back off the prism set screws as far as stop permits. Tighten clamping screw slightly and instrument is properly set.

Scale—This is illuminated with electric light connected to 110 Volt light socket. The graduations are in units of 0.00001″ per inch of gage length.

Telescope—This is mounted at opposite end of bracket from the scale. It is equipped with screw adjustments for vertical and horizontal tilts and ocusing.



Extensometer being Calibrated.

Thread Snap Gage

C. V. Johnson*

THE function of a limit thread snap gage is to facilitate the production of interchangeable and dependable threaded parts. The application should effect a preventative medium against producing incorrect threads rather than a means for detecting and sorting correct and incorrect screws.

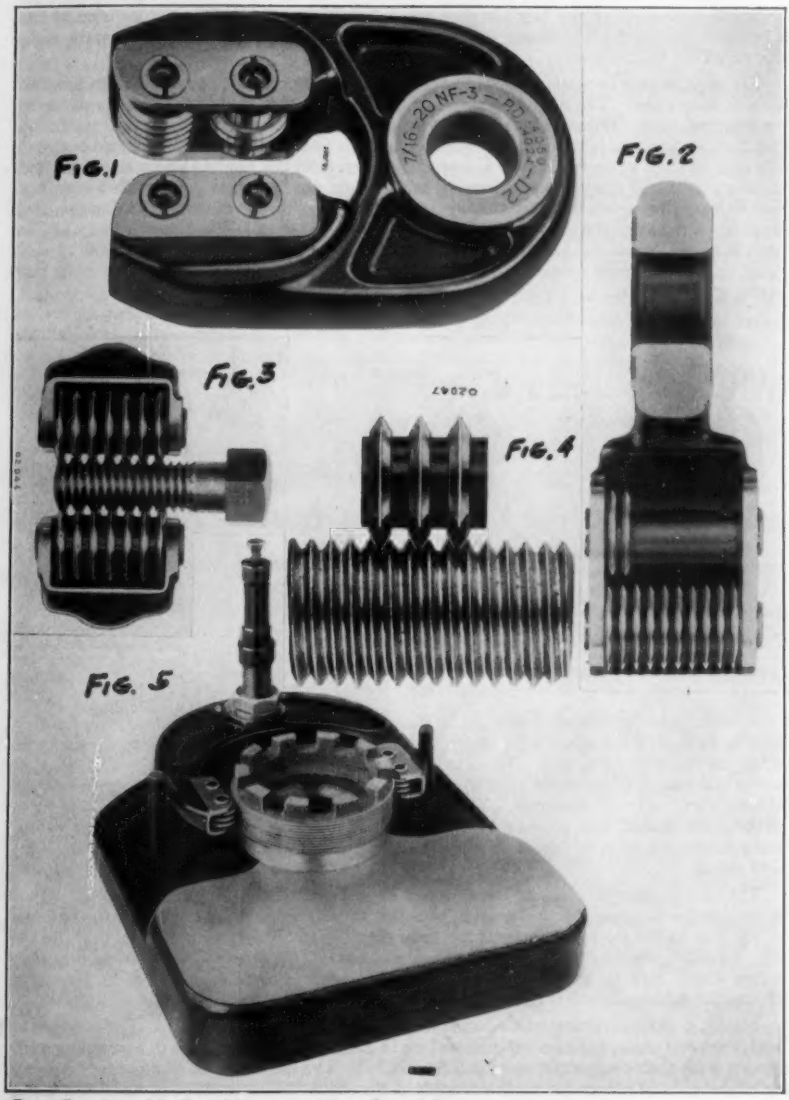


Fig. 1. Face view of the Gage showing arrangement of gaging elements.
Fig. 2. Split view of the Gage showing arrangement of Go and Not Go Rolls.
Fig. 3. Lead error of Screw—visible check.
Fig. 4. Shallow thread—produced, usually, by worn threading tools.
Fig. 5. Showing application of gage and gage fixture for checking large diameter shell threads.

*Pratt and Whitney Company

Interchangeability is an economical requisite primarily, in that the main virtue of this characteristic is the elimination of the necessity of pairing up mating parts and the excessive time required by such a process. Interchangeability is controlled by the Go gage which represents the maximum dimension of the male thread. The purpose of the Go gage, primarily is to assure that the screw thread is sufficiently small to avoid assembly interference.

Dependability is fundamentally a mechanical consideration and is contingent upon accuracy. It is essential for in many instances the performance of a mechanism is measurably proportional to the degree of efficiency with which its threaded members serve their purpose. Dependability is controlled by the Not Go gage which establishes the minimum dimension of the screw and the maximum looseness which can exist between the mating threaded parts without impairing their efficiency.

The gage, as may be seen in Fig. 1, embodies the conventional "U" shaped design common to limit snap gages. The gaging elements are annular ribbed rolls and are rotatably mounted on eccentric pins. The outstanding advantages of the annular ribbed and freely rotable roll are, first, a considerable reduction in wear on the rolls due to elimination of friction between the gage and the screw being gaged; second, freedom from the binding and cramping action common to thread snap gages employing fixed gaging points or flat jaws, with a result of greatly increased speed in the gaging operation over other types of thread snap gages; and third, adjustment of the gage, which amounts to .040" in sizes ¼" and larger, and .016" in sizes between No. 0 and 12 N, affords a compensating medium for such slight wear as may occur in the rolls after considerable use, or as may be necessitated by changes in pitch diameter specifications.

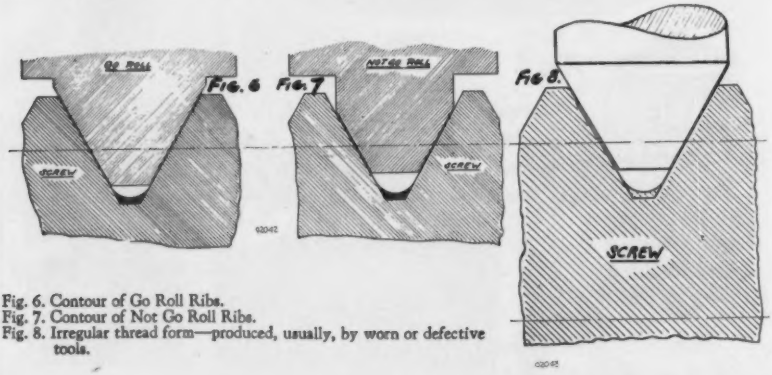


Fig. 6. Contour of Go Roll Ribs.
Fig. 7. Contour of Not Go Roll Ribs.
Fig. 8. Irregular thread form—produced, usually, by worn or defective tools.

In addition to the durability afforded by the principle of the gage which employs a rotatably mounted roll, and the speed with which thread gaging may be done, its design incorporates other essential features also. To determine the interchangeability and dependability of screw threads, it is necessary that the design of the gage contribute more than sustained accuracy and speed of operation. The gage must be designed so that the several elements of the screw thread, lead, maximum and minimum pitch diameters, form, angle, concentricity, and straightness, upon which interchangeability and dependability are dependent, be analysed and gaged.

The Go roll has a plurality of gaging ribs. This arrangement permits the checking of lead as well as the maximum pitch diameter, to which the Go rolls are set. Further, the contour of the ribs on the Go rolls represent the form required to obtain assembly, Fig. 6. The Go roll, therefore, checks collectively the several elements of the screw thread, and assures that errors which may be present are compensated for to eliminate interference in assembly. Hence, interchangeability is controlled by the Go gage.

Figs. 3, 4 and 8 illustrate errors common to the commercial screw thread. These errors of lead, form and angle, must be compensated for in order that the difficulties in assembling such screws with their component parts will be avoided. The usual way of eliminating assembly interference is to reduce the pitch diameter of the screw. This process, in many instances, impairs the dependability of the thread. Therefore, the Not Go gage which controls this factor must be designed specifically to gage the minimum pitch diameter of the screw.

The Not Go element contains but two ribs; this avoids interference from lateral and lead errors, checking a diametrical dimension only. The contour of the Not Go roll is illustrated in Fig. 7. This design obviates the possibility of erroneously gaging the effective pitch dia-

meter of a screw thread, and it also assures that the pitch diameter will not be reduced below the permissible minimum size due to the interference of form and angle errors illustrated in Figs. 4 and 8.

Out-of-round threads, especially in the large diameter threads illustrated in Fig. 5, are very common. The elliptical condition causes an excessive strain on the threads at the points of contact with the mating part, which, of course, is at the largest diameter only. The ring thread gage, with its peripheral engagement, cannot detect this condition. A gaging means having diametrical contact, such as afforded by caliper or snap gages, is the only means by which it can be detected.

To check for out-of-roundness, the piece is passed between the Go rolls and into contact with the Not Go rolls. While engaged with the Not Go rolls the piece is given a quarter turn; should the screw be undersize at any point it will drop between the Go rolls; should the screw be oversize at this newly presented cross-section it will not pass between the Go rolls. By this process out-of-roundness is detected.

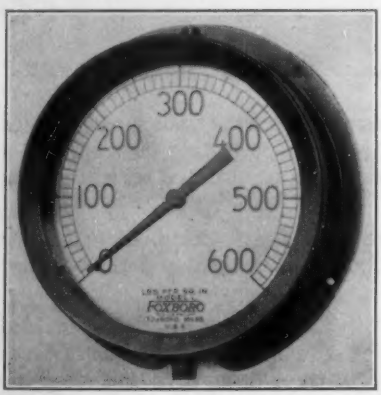
Straightness of a screw thread is determined by bringing both ends of the screw into contact with the Not Go rolls. With the ring thread gage a tapered condition may escape detection as the Not Go ring may not start on the thread, the screw being up to size on the end presented to the gage, while the other end of the thread, which cannot be brought into contact with the gage, may be undersize due to back taper.

The gage is built in sizes to cover the range of threads having major diameters $\frac{1}{16}''$ and larger. A feature of this gage is that its application is not limited to a narrow size range, but that it functions equally well in small, intermediate, and large size threads.

In order that the many special conditions in threaded parts may be correctly met, all sizes of gages are built in several styles. Hence, the gaging requirements for threads having unusual lengths of engagement, threads approaching shoulders and leaving but a minimum recess or clearance, short threads, etc., are fully met by the various styles.

New Pressure Gage

THE Foxboro Company has recently developed an indicating pressure gage that makes use of a special alloy steel bourdon spring and a hardened steel movement. It is designed specifically to last many times longer than the present type of indicating gages on the market. It meets the modern demand for uninterrupted service. Once installed, it will give precision accuracy without fear of breakdown.



All the parts of this new gage are alloy steel and are screwed tightly into place. This insures against leaks developing due to high pressure, high temperature conditions. This gage will not let go. It will not spray injurious fluids on workmen or machinery nearby.

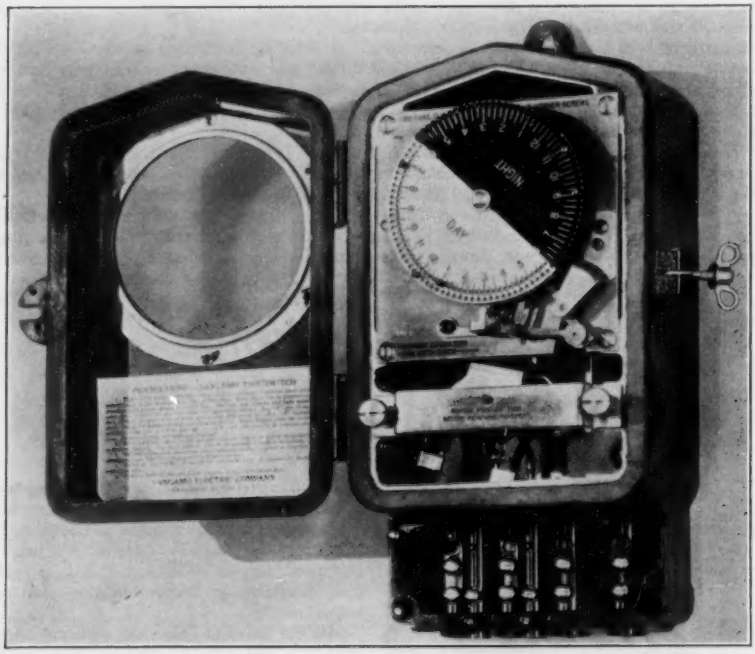
Particular care has been taken in the detailed construction of this indicator. Besides the chrome-molybdenum bourdon spring which allows this gage to be operated continuously at maximum scale reading without fatigue there are many other features. The flanged case is of cast iron and is made 100% fume tight. It has a cast iron threaded ring fitted with double thick glass litharged in place. The movement of the gage is all steel and care has been taken to make it extra sturdy. It has cadmium plated movement-plates, steel hair spring, extra wide bearing surfaces and hardened steel parts to withstand vibration and excessive pulsation. The dial and pointer are of stainless iron which insures permancy and no discoloration.

This gage is furnished only in a 6" size with bottom connection, forged steel socket, $\frac{1}{4}''$ male S. P. T. Pressure ranges available at the present time are: 0-300, 0-600, and 0-1000 lbs./in.^{2}.

New Time Switch

(Sangamo Electric Co.)

ESSENTIALLY, the Sangamo time-switch is an electrically-wound clock arranged to trip a mercury switch. The clock mechanism is a standard movement, in which the mainspring is kept wound to a constant tension by a noiseless clock motor.



High precision is assured by a jewel escapement, which is compensated for all variations of temperature, and provided a protecting dustcap, and a micrometer fast or slow adjustment which can be operated without necessitating removal of the dustcap.

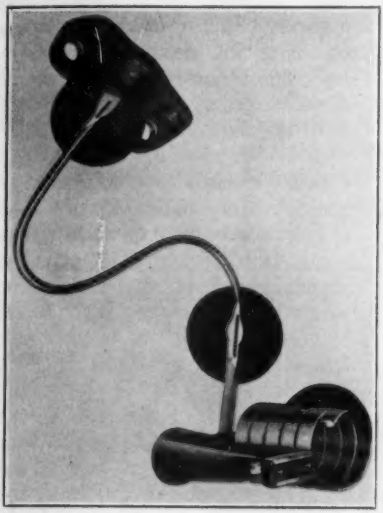
The switch mechanism is motivated by the mainspring through a differential gear, so that current interruptions affecting the motor will not affect the action of the mainspring.

For the purpose of setting time intervals, the time-switch is provided with a 24-hour dial, in the outer edges of which are two rows of holes . . . 96 holes to a row. Pins inserted in these holes open and close the switch. The period of operation can thus be varied from one "open" and one "close" in the 24-hour cycle, to one operation every fifteen minutes.

These time-switches are available for any commercial voltage or frequency a.c. or d.c. The motor constitutes the only difference between an a.c. and d.c. switch. A conduit-connected base, or meter terminals are furnished according to the specific need.

Steel Spring Recording Gages

THE Foxboro Company during the current year perfected an alloy-steel helical spring movement for their recording gages. This new Foxboro gage movement is of one piece tubing—all steel and all welded. It combines maximum safety with high resistance to commonly encountered corrosive agents. One of these new alloy-steel helical movements is illustrated. There is no solder—no brass used in this movement's construction.

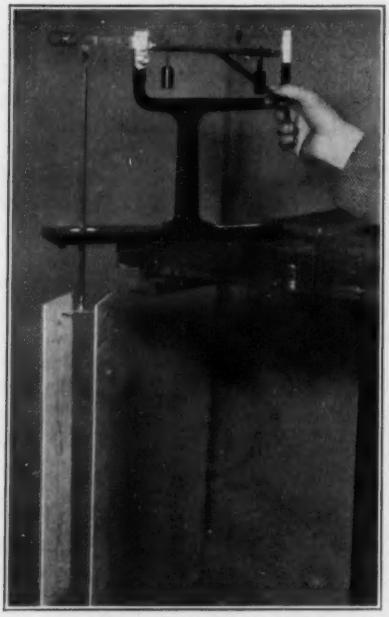


All steel parts—all welded connections mean safety. High temperatures—high pressures can also be withstood better by these gages with the result that there is no danger of them letting go to spray hot fluids on workmen nearby. Besides the safety feature, these steel spring gages allow uninterrupted service—they will last longer under the most trying conditions.

The Foxboro steel alloy movement is no longer in the experimental stage. During the past two years these steel welded movements have been placed on high pressure work in central stations, casing and tubing work in the natural gas field, cracking units in refineries, various processes in air reduction plants and on processes and in power plants in numerous other industries. The result has been that after continuous operation in the field The Foxboro Company has found their instruments equipped with these steel helicals to be accurate to within less than 1%. The new movements are used on gas, water, steam, oil, air, brine, chemicals, etc., where the pressures do not exceed 2,000 lbs. / in.^{2}

Wood Moisture Balance

THE wood moisture balance, a simple device for reading directly the trend of moisture content of wood in the woodworking shop, dry shed, or storage shed, is a recent contribution of the U. S. Forest Products Laboratory to wood seasoning technique. The value of the device is based on the well-known fact that there is a definite moisture content for wood—the equilibrium moisture content—corresponding to any given combination of relative humidity and temperature; the equilibrium moisture content of wood in a room at 70° F. and 30% relative humidity is, for instance, a trifle over 6%.



For measuring the moisture content which the wood near by is attempting to reach—a good gage of the severity of drying conditions—reading of the balance is much more simple and direct than cutting and determining moisture content on wood samples or computing atmospheric humidity and corresponding wood moisture from wet-bulb and dry-bulb thermometer readings.

The wood moisture balance consists essentially of any kind of simple balance on one side of which is suspended a strip of wood cut to a calculated weight of exactly 100 grams, ounces, or other convenient unit when oven dry. If the wood is thin—say 1/8" in thickness—and its oven-dry weight is offset by a corresponding weight on the opposite side of the beam, the moisture which it picks up to come to equilibrium with the surrounding air can be determined directly in % of oven-dry weight of the wood by balancing the wood with weights added to the 100 units already on the opposite side of the beam. In the case of a spring balance, subtracting the oven dry weight of the wood from the reading would give the moisture %.

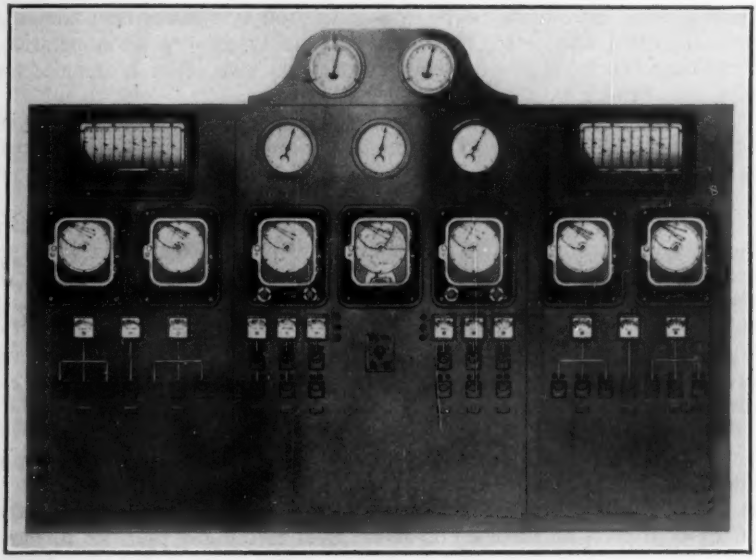
Equipped with a very thin strip of wood the wood moisture balance acts quickly enough to be said to show equilibrium moisture content practically at the moment of reading. Provided with a thicker piece which changes more slowly, any given reading averages the effect on the wood of atmospheric conditions for some time (length of time increasing with thickness of the wood) previous to the reading. When special sensitiveness is desired it is best to use sapwood of a species which responds quickly to moisture changes.

The Hays Corporation of Michigan City, Indiana, has begun construction of a new steel and brick foundry building adjoining their present factory to provide an additional 6000 square feet of space.

Bailey Meters and Control at Rouge Plant Ford Motor Company

EARLY in 1931 a complete system of Bailey Meters and Control will be installed on the new high pressure power-generating units at the Rouge Plant of the Ford Motor Company.

Increasing power demands at this plant have made it advisable to replace some of the older equipment with modern units of larger capacity. One new General Electric turbine of 110,000 kw. capacity will be supplied by 2 new pulverized coal fired boilers. Each boiler unit, consisting of 2 double-set boilers with 32,040 ft.^{2} of water heating surface, will be able to deliver a maximum of 700,000 lbs. of steam per hour at 1350 lbs. / in.^{2} pressure and a temperature of 750°F.



The operation of Bailey automatic combustion control as applied to these boilers is interesting. Variation in steam pressure, which is a function of the load, actuates the master pressure contactor. When the steam demand increases above any given load, the master pressure contactor at once sends out impulses to mechanical operators calling for more fuel and more air for both boilers. The mechanical operators (control drives) supply more air by proper speed regulation of forced and induced draft fans and by regulating the position of the dampers. More fuel is supplied by increasing the speed of feeder motors and proportionately increasing primary air by properly opening dampers in the primary air ducts. Impulses for less coal and air are sent out from the master contactor in case of a rise in steam pressure, which indicates a decrease in steam demand. Thus the system tends to make each boiler take its share of load changes and maintains substantially equal ratings at all times.

The above changes in fuel and air will tend to maintain the pressure at the desired figure; however, it is important that the proper relation between fuel and air exists at all times in order to produce the maximum amount of steam from the coal burned. This necessitates individual boiler control. If a slightly improper relation exists at either boiler, the individual boiler control makes the necessary readjustments in the induced draft so that the air supply is consistent with best combustion conditions. Any deviation from normal furnace draft calls for a readjustment in the forced draft, thus maintaining the furnace draft at the desired figure.

There is the possibility of push button control, automatic control, or manual operation on the fuel and air at each boiler. From the master drum switch, push button control may be had on both boilers together; whereas from the individual boiler drum switch, push button control may be had on fuel or air independently or collectively on that particular boiler. Various positions of the drum switches will permit either boiler to be on full or partial automatic control, push button control, or manual control independent of the method of operation of the other boiler. At each individual control drive located at the point of operation is a handwheel allowing manual control of the factor, should the electrical system become inoperative. From the foregoing it may be easily seen that the installation is designed for maximum flexibility.

In addition to this combustion control system, Bailey automatic control equipment will be applied to control boiler feed water, feed water pumps, reheater condensate level, and drainage. All of these systems are designed so as to be flexible in their method of operation.

On the steel panel board of each boiler unit will be mounted a boiler meter, 2 combination feed water meters and boiler drum water level recorders, and 2 water level indicators. Four recorders will give records of the temperature of the feed water, flue gas and air at the inlet and outlet sides of the economizers and preheaters located at either side of the boiler. Two 10-compartment multi-pointer gages will indicate various drafts and pressures. This equipment will give complete information as to the performance and operation of the boiler unit.

The turbine panel will also be equipped with several Bailey meters. Two fluid meters will measure the steam flow in each of the turbine supply lines, and a third fluid meter will measure the steam flow to the reheater. A recorder will record the pressure of the steam at the inlet and discharge of the high pressure turbine and at the inlet of the low pressure turbine. Another recorder will record temperature of the steam at the inlet to the high pressure turbine, at the discharge of the high pressure turbine and at the discharge of each of the steam reheaters.

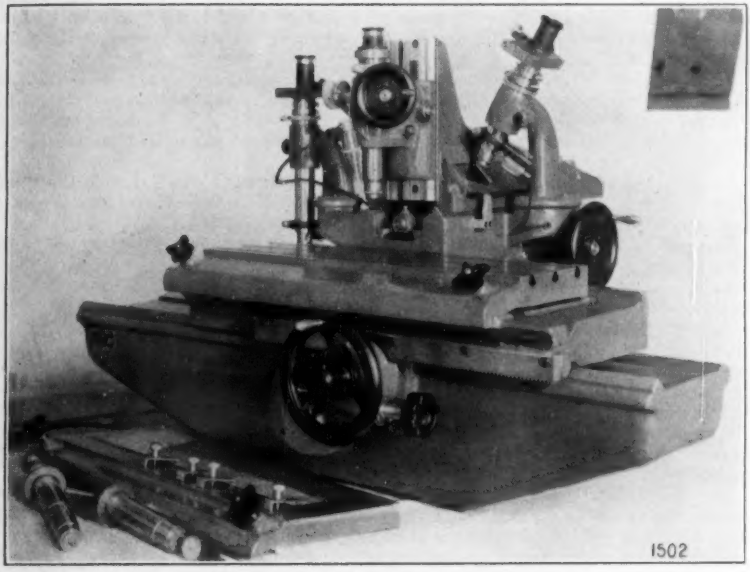
The Bailey Meter Company of Cleveland, Ohio announces that the rapid growth of its business in the Pacific Northwest has necessitated the opening of an office in that section. This office has been located in Seattle, Washington, at 406 E. 80th Street, and is under the management of L. E. Evans.

Bailey Meter Company of Cleveland, Ohio, announces that C. E. Albert has been appointed manager of the Kansas City Office located at 1010 Coca Cola Bldg., Kansas City, Missouri. Mr. Albert was previously located with the Houston Office, Texas.

Universal Two-Co-ordinate Measuring Machine

(R. Y. Ferner Co.)

THIS new type measuring machine is for general use in inspection departments of industrial plants. It is arranged to carry out measurements in two co-ordinates and can be used for measuring all kinds of workpieces, such as forming tools, profile gages, templets, cams, small jigs, thread cutters, dies, etc. Provision is also made for testing of thread gages, micrometer screws, worms and taps for pitch, angle of profile and diameters by means of an optical method. Measurements may also be made of photographic negatives or prints or any type of recorded charts, such as oscillograph films, X-ray pictures, spectrographic plates, ballistic charts, thermographic and dilatometric tracings, etc.



Measuring Machine made by Société Genevoise showing T-slotted table in position, with interchangeabl glass-topped table at front of machine.

The precision of the apparatus is embodied in 2 accurately graduated scales of nickel-steel alloy containing 58% nickel which has the same coefficient of expansion as the steel parts which would generally be measured on the machine. This material takes a high specular polish on which precise microscopic lines can be ruled. It is highly resistant to corrosion and the scales are therefore permanent and not affected by wear.

A heavy cast iron bed supports the 2 slides which move at right angles to each other on Vee and flat ways. The longitudinal slide has a useful travel of 16″. This motion is accomplished rapidly by a rack and pinion, using a large hand wheel at the front of the machine, while the fine settings for readings are made by a worm and worm wheel drive. The slide carries a 16″ precision scale in a fully shielded casing at the rear of the slide.

The readings on this scale are made by one of the Société Genevoise high precision micrometer microscopes reading to 0.00005″ per division. This scale is divided to twentieths of an inch throughout its length, so that at least one division of the scale is in the field of view in any position of the table, on which settings may be readily made. A coarse scale with index is mounted on the front part of the machine bed for approximate settings.

The longitudinal slide has an opening 16¾″ x 4⅝″ to permit illumination from below. The pieces to be measured are not clamped to this slide but to one of 3 interchangeable fixtures provided with the machine. One of these is a T-slotted worktable which can be clamped on the slide by means of two bolts with star handles. This cast iron table, 19¼″x5½″ is to be used for laying out work by means of the punching tool and for general measuring work or for

the attachment of any special work-holding fixtures. The T-slots are aligned accurately parallel to the direction of displacement of the slide so that they can be used for reference.

A second table that can be similarly bolted to the slide has a strong glass plate 16½″x3¾″ (420 x 95 mm) set flush with the surface over the opening in it. It is used for measurement of any objects with illumination from below, such as photographic plates, profile gages, templets, etc. Screw clamps are provided for holding pieces on this table.

The third fixture for attachment to the slide is a pair of center supports for the examination of pieces held between centers such as micrometer screws, worms and thread gages. The centerline is exactly aligned with the line of displacement of the slide.

A transverse carriage, moved on its Vee and flat ways by means of a screw, serves to carry the sighting microscopes for measurements in the other co-ordinate. The screw is not used as a measuring device, however. The carriage carries a precision scale like the one carried by the longitudinal slide, in construction, 4″ long, on which readings are made by a second micrometer microscope. These readings are to the same degree of accuracy as on the other scale. Readings on these scales are guaranteed accurate within 0.00015″ without necessity of applying any corrections to the readings for errors of the scales—or, by applying the scale corrections, of which a tabulation is furnished with each machine, one can obtain a higher accuracy, limited primarily by the precision with which sightings may be made on the object being measured.

The front part of the transverse carriage has a vertical slide on which the tool holder can be adjusted in height by means of a rack and pinion device. This tool holder is provided with a hardened and lapped sleeve insuring the correct fitting of the tools. A locating or sighting microscope, a goniometric microscope, a punching tool and a centering dial indicator device are designed to fit in this tool holder.

The locating microscope has a crossed reticle of threads which can be adjusted to insure exact concentricity with the bore of the tool holder. It is used for making all readings on photographic plates, charts and profile objects. Its tube is made of hardened steel.

The goniometric microscope, provided with a fixed cross thread and one which can be turned about the central axis, is used for measuring angles, especially the profile of screw threads. By its vernier these angles can be read to 1′ of arc. This microscope is also used for the optical measurement of the pitch and diameters of screw threads.

A device for illumination from below is carried by the transverse carriage, using a tubular piece extending through the bed of the machine from the rear. The illumination beam of parallel light is therefore always reflected upward in the axis of the sighting or goniometric microscope. This beam of light can be inclined to the mean helical angle of screw threads that may be measured.

A transformer for the illumination of the microscopes and a special illuminating collimator for illumination of opaque objects from above is furnished with the regular accessories of the machine.

The punching tool provides means of spotting the centers of holes to be bored on a separate machine and so may be used for the very precise laying out of jigs and dies up to 4″ x 16″ in size. Or it may be used for laying out profiles and contours of special gages, cams, etc.

The centering dial indicator, reading to 0.001″ and sensitive to a higher accuracy, can be used for aligning work or for measuring the distance between holes. The hardened sleeve of the indicator is ground exactly concentric so that in interchanging the indicator with the other tools the precision of the work is not affected.

The minimum free distance between the T-slotted table and the tool holder is 3″, the maximum 6¼″ while the distance from the table to the transverse carriage is 2$\frac{11}{13}$″.

A 6″ circular table, read easily to 1′ of arc, is furnished as an extra for those who want to work in polar co-ordinates.

An additional extra that may be had with the machine is a camera ludida of the Abbé-Apathy type, which can be used for drawing objects seen in the microscope or for checking their form against a chart or drawing.

The machine may also be used for the accurate checking of flat gage blocks by using 2 gage blocks having a fine line ruled on the surface of each. These can be wrung on the gage block or a series of blocks to be tested and the distance between the lines can be measured by reference to the scale on the longitudinal slide; then the two special blocks can be removed and wrung together for the measurement of the distance between their lines in this position, which quantity would, of course, be subtracted from the first measurement to obtain the thickness of the gage block in question.

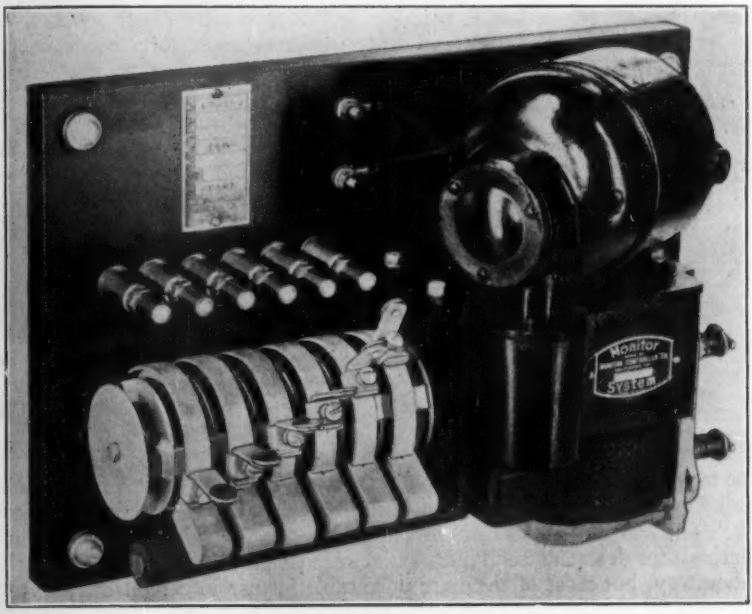
The machine can also be used for checking all kinds of rules, scales on vernier calipers, and the like, or for the measurement of diameter of wire and mesh of cement sieves, or for the counting of threads in textiles. The stretch of test specimens, on which lines have been ruled before test, can also be checked by means of this equipment. The center distance of gears in mesh or the dimensions of watch and clock wheels can be measured, or the diameters of holes in watch jewels.

Work-Cycle Timer

(Monitor Controller Co.)

THE Monitor work-cycle timer will start, stop, accelerate, decelerate, reverse, heat, cool, open, close, raise, lower . . . in short, do anything that can be done by electricity and do all these things in sequence and at definite time intervals that may be easily and accurately adjusted.

The most important characteristic of the Monitor work-cycle timer is that it can be reset instantly at the starting point at any time during, or after, the completion of the cycle.



The current-carrying switches in a given timer unit are all electrically connected on the pivoted side. Each individual switch consists of a rotable disk carrying an adjustable contact point and a post fixed on the panel and connected directly to the circuit to be controlled.

There are as many of these little switches as there are circuits in the sequence. The rotatable disks are mounted loosely on a sleeve which is carried on a revolving hollow shaft. Each such disk is between two rotating disks that are keyed to the shaft. These rotating disks are equipped with carbon blocks that bear lightly against the switch disks.

The rotating hollow shaft is driven by a constant-speed electric motor. Through its center extends a clutch rod that can be moved by the action of a powerful magnet.

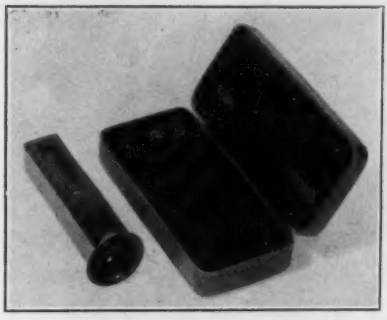
When the magnet is excited, the clutch rod is pulled to the right, and all the disks are pressed together, and pressure starting with the outside disk and passing through the whole line, so that there is exactly the same pressure between all disks. Then the switches rotate, being driven through friction by the driving disks.

Rotation of each switch continues until it closes on its stationary contact post. From that time on, it simply slips between its driving disks.

When the magnet is released, the pressure is removed from the disks and the reset weights cause all the switch disks to drop back to the normal rest position, ready to start again.

Ultra-Violet Radiation Indicator

THE U-V indicator, a small, fluorescent instrument produced by the Lighting Research Laboratory of the General Electric Incandescent Lamp Department makes it possible to compare ultra-violet sources, to inspect transmitting glasses and materials, and to perform other useful tasks. Simply by looking through the eyepiece of the indicator and letting sunlight or radiation from a G-E Sunlamp or other source of ultra-violet radiation fall upon a glass-covered slit on one side of the indicator, a design will be seen against a background of bright blue. If a piece of window glass is interposed, the blue field becomes much darker because of the absorption of the radiation. The new U-V indicator, a mottled dark brown molded instrument 3″ long, is furnished in a plush-lined metal case covered with imitation leather.



It seems established that a safe and effective substitute for sunlight for the maintenance of health and cure of certain diseases must contain adequate radiant energy in the spectral range from 2800 to 3200 A. U. and window glass absorbs most radiation shorter than 3200 A. U. Many complex methods for detecting such ultra-violet radiation are available for use in the laboratory, but most of them are unsuitable for use in demonstrating it to the general public.

The ultra-violet radiation passes freely through a piece of dark glass, practically opaque to visible radiation, and produces a deep blue fluorescence in another piece of special glass behind the dark glass in the new instrument. Its maximum sensitivity is at a wave length close to that of maximum effectiveness in the production of erythema (reddening and tanning of the skin) and is in the region of the wave length of maximum antirachitic effectiveness, so that its spectral range encompasses that of established biological importance.

Since midsummer sunlight contains ultra-violet energy only at the long-wave end of the spectral range, 2800 to 3200 angstroms, where the U-V indicator is somewhat more sensitive, the blue field will be appreciably brighter with sunlight than with an artificial source of biologically-active ultra-violet of equal value. When the window-glass test is applied to sunlight the blue field is darkened, but not as much relatively as when a source such as the G-E Sunlamp is used, thus demonstrating that nearly all of the fluorescence caused by the latter is of wave lengths shorter than 3200 A. U.

New Electric Gage

AN electric gage which measures one one-hundred thousandth of an inch, and then magnifies that infinitesimal dimension 10,000 times so that the average workman may speedily and accurately read the result, has been developed by the general engineering laboratory of the General Electric Company.

ELECTRIC GAGE HEAD TO MEASURE INSIDE DIAMETER OF AUTOMOBILE CYLINDER BORE, ALSO 2 MASTER RINGS

ELECTRIC GAGE HEAD AND STAND FOR MEASURING THICKNESS OF SHEET METAL, PAPER, ETC.

ELECTRIC GAGE HEAD AND FOR MEASURING OUTSIDE DIAMETER, ALSO 2 MASTER DISCS

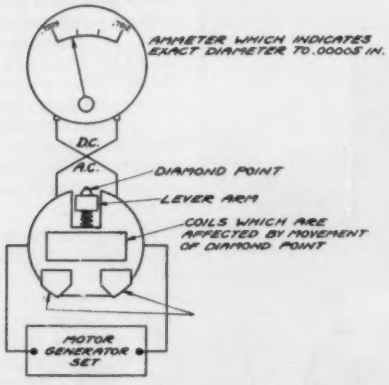
To make such accurate measurements is usually slow and laborious work. By a method of speeding up measurements where production is great and the need of accuracy to minute proportions is imperative, costs of production would be reduced materially. That is what the electric gage does —first it measures and then instantaneously it multiplies the measurement so that it can be read easily.

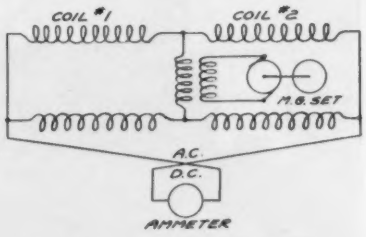
To gage the crankpin hole in pistons, the piston is placed over a spindle and rotated once, while the operator watches the pointer on a scale. Approximate limits beyond which the work is rejected are indicated, the "accept" limit in this case covering 3″ on the scale and representing three ten-thousandths of an inch on the work. The gage can pass hundreds of thousands of pistons with no renewal or re finishing of parts, whereas the usual paddle-type "go" and "no-go" gages formerly used passed only 400 pistons before requiring refinishing.

The new gage is suitable for almost any type of measurement, with certain changes in the set-up. It may be used to measure outside dimensions of automobile wrist-pins, the inside dimensions of automobile cylinders, and the thickness of flat materials such as sheet steel or paper. One interesting ap-

plication in the General Electric refrigeration department is a set-up to measure the distance between the center lines of two holes in the main frame of a motor, to determine the parallelism of their center lines.

The gage consists essentially of a contact point supported to move through a limited distance in the direction of measurement, say 0.0005". This movement causes a pointer to travel 5" over the scale of an indicating instrument. The 10,000 times magnification of movement is obtained by unbalancing a bridge circuit of 4 inductances. A 500-cycle alternator supplies power to a small transformer which, in turn, supplies power to the 4 inductances. Two of these are small coils in the electric gage head, which is about 5" x 2½" x 1½" in size. The inductance of these is varied by the movement of a pivoted steel lever armature, one end of which moves between the coils as the contact point on the other end conforms to the surface of the piece being measured. The contact point is in the gage spindle, which is made to fit the work. The other 2 inductances of the bridge, together with the transformer and indicating instrument, are mounted in an indicating unit, 12" x 12" x 12" in dimensions, which is placed in easy view of the operator.





(*Above*) Connection Diagram of Electric Gage.

At Right) Schematic Representation.

The long life of the spindle of the electric gage has been obtained by having the bearing surfaces made of cemented tungsten carbide. The contact point which explores the piece is a diamond. The contact pressures are sufficiently low so that the material being gaged will not be scratched.

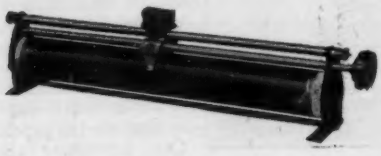
The gage is calibrated in place simply by adjusting the distance between 2 small coils in the gage head so as to bring the pointer on the scale as desired. This is done with suitable master ring gages of the minimum and maximum limits. In applying the gage to the innumerable varieties of parts in present-day production the indicating unit, gage head and power supply are similar for practically all applications. The spindle and the mounting of the gage head vary with the application.

Recording instruments for use with the electric gage are being developed; and relays for controlling operations based on thickness of material can be applied.

New Improved Tubular Rheostat

(*Hardwick, Hindle, Inc.*)

AMONG the novel features which may be mentioned are first: the crew engagement mechanism is so arranged that the act of grasping the knob to adjust the slider by hand automatically disengages the screw engagement mechanism.



This mechanism is self-supporting, self-aligning, no binding. The heavy phosphor bronze contact shoe maintains firm contact with the wire but cannot tear it. Due to new spring arrangement on the contact shoe there is no current carried through it, consequently the pressure springs cannot overheat.

New Exhaust Gas Analyzing Device

(Miller Reese Hutchison)

DURING the past decade, a number of investigators have shown the value of chemical analysis of automobile exhaust gases, as a means for adjusting the fuel-air ratio of the engine carburetor, to obtain economical and efficient performance.

Fig. 1 shows graphically the percentage of carbon monoxide and total combustibles present in the exhaust gas with various air-fuel ratios. It shows also the completeness of combustion corresponding to the percentage of carbon monoxide present.

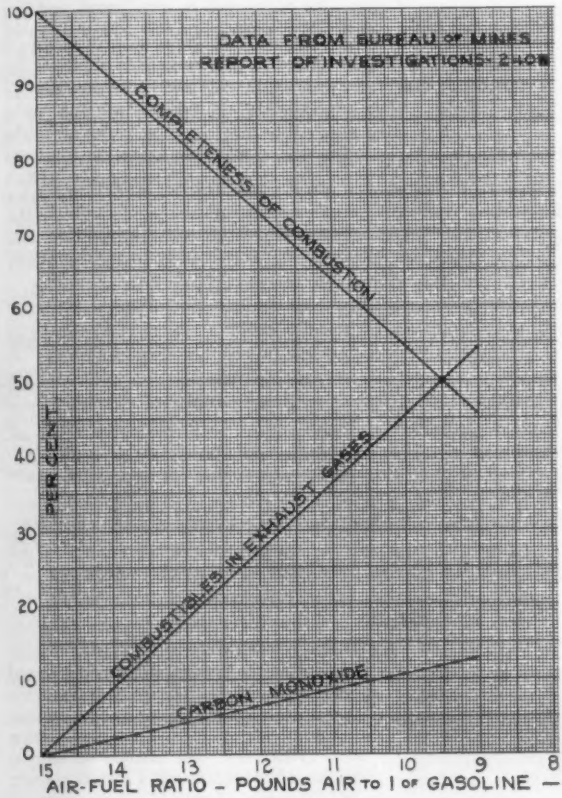


Fig. 1

Chemical analysis, could of course have a very limited application, on the automotive field, by its nature being confined to laboratory tests and investigations.

Moto-Vita is a simple, compact instrument, by means of which, a continuous indication of the exhaust gas composition is obtained.

With this instrument installed on an automobile, airplane, or motor boat, the carburetor can be adjusted, under actual operating conditions, to obtain the most efficient and economical mixture.

The instrument consists of 2 principal units, the analyzer and the indicator. The analyzer is a tubular housing which is connected directly to the engine exhaust pipe. The pressure existing in the exhaust pipe, forces a small amount of the exhaust gases into the housing, to act on the sensitive element, which is a small replaceable unit mounted within the housing. The indicator is a small milliammeter, with a scale specially calibrated to show the percentage of fuel being wasted, due to improper mixture adjustment. This indicator can be mounted in any convenient position, preferably with the usual instruments on the dash, or instrument panel.

Fig. 2 shows in diagrammatic form the electrical connections of the 2 units. The analyzing element, sensitive to changes in exhaust gas composition, is made up of 4 metal wires, connected as shown in Fig. 2 in the well known "Wheatstone" bridge circuit.

Wires A and D are the active, or catalytic wires. These are made of platinum, or other similarly catalytic metal. Wires B and C, the inactive side of the bridge are made of nickel or any other non catalytic metal the resistance-temperature characteristics of which are approximately the same as platinum This gives a bridge that is not affected by changes in exhaust gas temperature.

Current from the battery K heats all 4 wires to a temperature, wherever the platinum wires A and D will catalyticly promote on their surface, combination with oxygen, of any carbon monoxide, hydrogen, methane, or gasoline vapor present in the exhaust gases.

Wires A, B, C, and D are of equal resistance normally. The circuit is thus "balanced" and the indicator M shows a reading of zero. When the exhaust gases, acting on the sensitive element, contain combustibles (carbon monoxide, and hydrogen mainly) the platinum wires A and D will catalyticly burn them. The heat developed by the reaction will be absorbed by these wires with a corresponding increase in temperature. As their resistance increases with increased temperature, the bridge will be unbalanced, and the indicator M will give a deflection, the value of which is a measure of the heat absorbed by the wires. Wires B and C, being non-catalytic remain unchanged in resistance. As the heat given off by the reaction, is a quantitative effect of the combustible concentration of the exhaust gases, the indicator will show directly the percentage of combustibles present in the exhaust. Thus the scale can readily be calibrated to show the present of fuel wasted. Test made over a period of 2 years have confirmed the value of the indicator scale, in terms of percent fuel wasted, under all normal operating conditions. In addition the instrument has been tested under actual operating conditions, on both automobiles, and airplanes to insure its ability to perform continuously, and satisfactorily under the severe demands of this service.

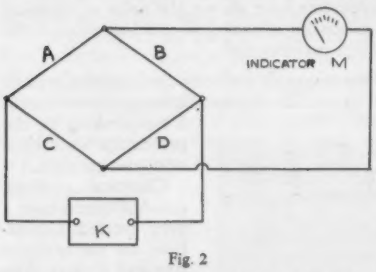
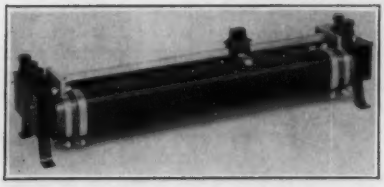


Fig. 2

Slide Wire Model Control Transformer

(Herman H. Sticht & Co.)



THIS transformer consists of a double laminated iron core with primary and secondary winding. The slider makes contact with the secondary which gives a continuous and uninterrupted voltage regulation from 0 to 40 volts. The primary winding is inside of the secondary and a special housing is not necessary as only low voltage (maximum 40 volts) is exposed.

These transformers may be connected selectively to either 110 volts or 220 volts, 60 cycles as 4 terminals are provided in the primary enabling series or parallel connection of the 2 halves. Two different types are available, one giving a maximum secondary voltage of 20, the other of 40 volts with technical data as per following tabulation:

	Type I	Type II
Primary Connection	110 and 220 volt 60 cycles	110 and 220 volt 60 cycles
Continuous output	400 V. A., 10 amps. at 40 volts	400 V. A. 20 amps. at 20 volts
Maximum current output	10 amps. continuous 20 amps. for 5 minutes	20 amps. continuous 40 amps. for 5 minutes

Dimensions: 21" x 4¾" x 4¾"; Weight 23¾ lbs.

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CONTROLLER. A folder illustrating and describing the L & N Anticipatory Controller, which corrects for variable quantities and maintains heat balance continuously and accurately. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

INSTRUMENT INVESTMENT NEWS. Vol. III, No. 7 of this publication contains the following articles: Keeping Farm Produce Fresh with Duplex Recording Thermometers, Instrument Maintenance, Relief Valves Prevent Bursting of Gas Compressors, Pasteurizing Milk Properly with Recording Thermometers, Gauge Tester for Measuring Pressure Capacity of Bottles. Consolidated Ashcroft-Hancock Co., Inc., Bridgeport, Conn.

SAFETY TONGS. This leaflet describes laboratory safety tongs in set of four tongs, one each for beakers, flasks, evaporating dishes and casseroles, thereby providing the safety equipment for performing the chemical operations most common to laboratory work. Fisher Scientific Company, Pittsburgh, Pa.

PYROMETER. A circular describing and illustrating the Leeds & Northrup Potentiometer Pyrometer. It deals directly with the electrical pressure (millivoltage) generated by the thermocouple, and this directness is basically responsible for its accuracy. It weighs the millivoltage of the thermocouple at first hand. It eliminates opportunities for error. Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa.

CURRENT TRANSFORMERS. Bulletin No. 930 describes the characteristics and advantages and technical data of the Universal Current Transformers. The Esterline-Angus Co., Indianapolis, Ind.

THERMOMETERS. A leaflet describing a new red reading mercury whose glass colors the mercury column to show a bright red instead of the regular silver-mercury. It is accomplished by means of reflection. The mercury is not disturbed or harmed by adding any chemical to change its color and you have the effect of reading a bright red column, with all the valuable properties of pure mercury. The Palmer Company, 26 Clay Street, Cincinnati, Ohio.

WATSON'S MICROSCOPE RECORD September 1930, No. 21 of this publication contains some of the following articles: Current Microscopy, The Microscope as a Geological Time-recorder, and The Linnescope, which is a new field microscope. W. Watson & Sons, Ltd., 313 High Holborn, London, W. C. 1.

MONOCHROMATOR. A circular illustrating and describing Van Cittert's Quartz Double Monochromator. P. J. Kipp & Zonen, Delft, Holland.

MIRROR EXTENSOMETER. This leaflet illustrates the mirror type extensometer. Riehle Bros. Testing Machine Co., 1424 North 9th St., Philadelphia, Pa.

TACHOMETERS. Catalogue No. 46 contains 16 pages with illustrations covering indicating and recording tachometers in various models. Brown Instrument Company, 4901 Stenton Ave., Philadelphia, Pa.

AUTOMATIC SWITCHGEAR. Leaflet No. GEA-1193A describes the application and operation of automatic switchgears. General Electric Co., Schenectady, N. Y.

SPECTROGRAPH. This leaflet describes a spectrograph of great intensity. P. J. Kipp & Zonen, Delft, Holland.

PROMI MICROSCOPE. A circular describes and illustrates a new microscope. Clay-Adams Co., Inc., 117 East 24th St., New York, N. Y.

TRANSFORMER. GEA-1269A announces the new G-E transformer. General Electric Co., Schenectady, N. Y.

THE MECAPION. A booklet entitled, "The Mecapion, An Ionisation Apparatus for the Absolute Measurement of X-Ray Dose." Adlanco Industrial Products Corp., 54 Lafayette St., New York, N. Y.

TEST OSCILLATOR. A leaflet illustrating the 180 Test Oscillator. Burton-Rogers Co., 755 Boylston St., Boston, Mass.

RESISTANCE TESTER. A leaflet describing and illustrating Type 561 Portable Resistance Tester. Hoyt Electrical Instrument Works, 755 Boylston St., Boston, Mass.

CIRCUIT TESTER. Circular LL-25M describes Model 563 DC Circuit Tester, which is used for resistance measurements and continuity tests. Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J.

RECORDERS. Two circulars one entitled, This L & N Temperature-Difference Recorder, and the other L & N Load Recorders Help Dispatchers Follow Load Schedules. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

QUICK WEIGHING PRECISION BALANCE. This leaflet describes the quick weighing precision balance instrument. Van Julian H. Becker, Delft, Holland.

HIGH PRESSURE MANOMETER. In this circular is described the application, construction and installation of high pressure manometers. Morey & Jones, Ltd., 922 South Hemlock St., Los Angeles, Calif.

MAGNET STEEL. A reprint from the July 1928 issue of the Journal of the Optical Society of America and Review of Scientific Instruments entitled, "An Improved Permeameter for Testing Magnet Steel." Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

PYRO-LANCE. Bulletin 530 shows the application and use of the Alnor Pyro-Lance. Illinois Testing Laboratories, Inc., 141 W. Austin Ave., Chicago, Ill.

PHOTOELECTRIC CELLS. A folder illustrating 4 new visitron photoelectric cells, charts showing their electrical characteristics, also the application of visitron cells is described. Bulletin 122 illustrates and describes the photoelectric cells in chemical technology. G-M Laboratories, Inc., Grace and Ravenswood Ave., Chicago, Ill.

PHOTOELECTRIC AMPLIFIER-RELAY. Bulletin 123 describes and illustrates the amplifier-relay, its operating characteristic reliability in operation and its accessories and prices. G-M Laboratories, Inc., Grace and Ravenswood Ave., Chicago, Ill.

HIGH VACUUM APPARATUS. Bulletin No. 120 describes G-M Mercury Vapor Pump, Vacuum Bottles and Vapor Traps. G-M Laboratories, Inc., Grace & Ravenswood Ave., Chicago, Ill.

COMBUSTION METERS. Catalogue RA-31 covers combustion meters for CO_2, Draft and Flue Gas Temperature and Boiler Panels. This literature shows mounting dimensions, method of installation, operating principle and general appearance of the equipment. The Hays Corp., Michigan City, Ind.

GAS & AIR METERS. Catalogue No. 500 contains data covering recent developments in Gas and Air Meters. Republic Flow meters Co., 2240 Diversey Pkwy., Chicago, Ill.

LITTELFUSES. This catalogue No. 3 is devoted to Littelfuses used for delicate electrical equipment protection, especially in the range below one ampere. Littelfuse Laboratories, 1772 Wilson Ave., Chicago, Ill.

HYDROMETER. Bulletin B-331, November, 1930 describes and illustrates the Braun "Mudwate" hydrometer, which is used to determine the weight per cubic foot and specific gravity of mixtures of finely divided solids and liquids. Braun Corp. Ltd., 363 New High St., Los Angeles, Calif.

METERS. Bulletin No. 37 describes and illustrates the various Bailey meters. A partial list of the users are listed in the back of the bulletin. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

GAS SERVICE JOURNAL. The November issue of this publication contains the following articles: Another Slant on the Gas Industry by the well known Floyd Gibbons; Unaccounted for Gas; Natural Gas as Applied to Existing Manufactured Gas System and Frosting of High Pressure Regulators Due to Extreme Pressure Reductions. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

VALVES. Catalogue No. 2002 contains 18 descriptive and illustrated pages on automatic control valves, motor operated types. Bristol Co., Waterbury, Conn.

FORENSIC BALLISTICS. The title of Spencer Lens latest catalogue, which is devoted to the science of comparison and identification of firearms, bullets, etc. The apparatus described in the bulletin is the culmination of several years experience. It is submitted to those who are seriously interested in obtaining results in the identification and comparison of bullets, shells, fingerprints, handwriting, etc. Spencer Lens Co., Buffalo, N. Y.

METERS. A folder illustrating and describing Brown CO_2 Meters. It has photographs of plant men working with these meters. Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.

TEST JACK. Folder No. L. 20487 shows the application of the test jack for type OB detachable watthour meters. Westinghouse Electric & Manufacturing Co., Newark, N. J.

EXPERIMENTER. Vol. V. No. 6 of this magazine contains the following articles: The Frequency Stability of Piezo-Electric Monitors; A stroboscopic Frequency Meter and the back cover shows a Piezo-Electric Oscillator with temperature control. General Radio Co., Cambridge A, Mass.

ELECTRIC HEATERS. Leaflet TA-29 contains the Trent Line of Electric Heaters. Harold E. Trent Co., 439 N. 12th St., Philadelphia, Pa.

RECORDERS. A folder showing how graphic records are used as a guide to lower costs and higher quality. The Esterline-Angus Co., Indianapolis, Ind.

POTENTIOMETER PYROMETER. Folder showing that to save dross—to improve quality, temperature readings must be accurate. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

THE GRAPHIC. No. 1030 of this publication contains an article by Ottomar H. Henschel, entitled, "Plugging Leaks in Production." The Esterline Angus Co., Indianapolis, Ind.

POLAROGRAPH. This booklet shows the polarograph which is a self-recording machine for current-voltage curves. Published in Czechoslovakia, but printed in English. Dr. V. & J. Nejedly, Prague XIX, Vokovice, Husova tr. 76, Czechoslovakia.

AMPLIFYING EQUIPMENTS. A booklet describing and illustrating amplifying equipment for educational and commercial requirements. Ferranti, Inc., 130 West 42nd. St., New York, N. Y.

X-RAY SPECTROGRAPH. The August 1930 issue contains the story of Dr. Muller's improved x-ray goniometer spectrograph. Adam Hilger, Ltd., 24 Rochester Place, Camden Rd., N.W.1, England.

BAKELITE REVIEW. The October 1930 issue explains that Bakelite is only a registered trade name for a number of products made from materials manufactured by Bakelite Corp., 247 Park Ave., New York, N. Y.

BALANCES, SCALES AND WEIGHTS. Catalogue No. 1928 describes the various balances, scales and weights for chemists, assayers, jewelers, druggists and other comercial and scientific purposes. Henry Troemner, 911 Arch St., Philadelphia, Pa.

MICROSCOPES, MICROTOMES, DELINEASCOPES AND OPTICAL MEASURING INSTRUMENTS. A catalogue devoted to microscopes, microtomes, delineascopes, optical measuring instruments and accessories. Spencer Lens Co., Buffalo, N. Y.

SPECTROGRAPH. The leaflet dated May, 1930 is devoted to the new design vacuum grating spectrograph. Adam Hilger Ltd., 24 Rochester Pl., Camden Rd., London N.W.1, England.

PATENTS. A booklet presented to inventors and others interested in patents for inventions. It is a concise outline of the general principles of the patent system. Albert E. Dieterich, Ouray Bldg., Washington, D. C.

CELLS. A circular showing the Eppley standard cell which is a precision standard of electromotive force. The Eppley Laboratory, Inc., Newport, R. I.

RADIO TEST EQUIPMENT. A three page circular announcing the new line of radio test equipment. Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J.

COMBUSTION CONTROL. Leaflet Q-163 entitled, "Secure a rebate on your coal bill this winter and get more heat." Coppus Engineering Corp., Worcester, Mass.

FLOW METER. A card model illustrating the inductance bridge principle applied to flow meter design. Brown Instrument Co., 4482 Wayne Ave., Philadelphia, Pa.

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INSTRUMENTS BOOK SHELF

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Acoustics. A Text on Theory and Application. *By George Walter Stewart & Robert Bruce Lindsay.* D. Van Nostrand Company, Inc., New York, 1930. Cloth, 6 x 9 inches, 358 pages. $5.00

Here at last is a comprehensive treatise on acoustical theory which covers the important researches of the past decade and does not neglect the modern practical applications of the theory. The appearance of this book is timely, because we are now passing through the final stages of the transition from the older approach to the modern. In making this remark, the reviewer has in mind that in acoustics, far more than in other branches of physics, there were in the past 2 separate and somewhat antagonistic groups of investigators who spoke entirely different languages: the artisan-students who dealt with applications and empirically developed musical instruments, architectural acoustics and qualitative methods of measurement; and the austere theorists who, losing themselves in mathematical mazes, could not tell a band leader "how to fix that sour B-flat trombone." Today, *per contra*, there has sprung up a new generation of sound-effect technicians and other acoustical specialists who not only thirst for theoretical knowledge but delight in immediately applying it in miracles of radiotelephonic microphones and loud speakers, photographic film sound-recording and -reproduction, new musical instruments and other cultural contributions, as well as in such strictly utilitarian fields as the elimination of noise in appliances, machinery, rolling stock and other vehicles, and its exclusion from buildings and rooms. These engineers and others associated with the new acoustical industries will welcome this book. Indeed one may reasonably suppose that many of them are former students of Dr. Stewart or of Dr. Lindsay.

Dr. Stewart is professor of physics in the University of Iowa. This book is basically an outgrowth of special lectures which he gave in a graduate course in Electrical Communications at Yale University; but its final form is largely due to Dr. Lindsay, associate professor of theoretical physics in Brown University (formerly of Yale University) who used the manuscript as a text in a graduate course. This background accounts for the orderly and progressive arrangement not only of the 12 chapters but of the sections of each chapter. Questions and problems at the end of chapters appear, on brief scrutiny, to have been prepared with an amount of painstaking care unusual in modern text books on individual branches of physical science.

That the book is modern in manner as well as matter is evidenced by the fact that the material is in large measure presented by what is known in legal education as the case method. The style, too, (or should one say the "tone"?) is agreeably modern without being modernistic. Some of the more complicated theoretical deductions, such as details in the theory of horns, are relegated to the appendices and certain aspects of acoustical theory, readily available elsewhere, are omitted entirely. But continuity has not been sacrificed to achieve this result and throughout the chapters, moreover, one is delighted to encounter a profusion of cross-references, some at the end of paragraphs and some purposely inserted in the sentences of the body of the text. Instead of taking for granted a super-intelligent student the authors seem to know just where the limitations of the average memory and comprehension need a little bolstering. Thus, although an initial edition, this book exhibits to the practiced eye many evidences of having been tested by actual lecture-room use and in consequence carefully elaborated, revised and perfected.

This striving for perfection of presentation accounts for the fact that those particular subjects in which the readers of INSTRUMENTS, as a class, are interested, are distributed throughout all chapters. It is true that Chapter VIII, Acoustic Instruments and Measurements, emphasizes these aspects, but on every page of that chapter one finds necessary references (as many as seven on one page) to discussions in other chapters. As a matter of fact the whole book may without stretching be said to be a treatise on acoustic measurements and acoustic instruments.

The authors consistently adhere to the restrictions implied in the sub-title, "A Text . . ." As conspicuous as the profusion of references to other writers is the paucity of references to the manufacturers of the instruments and apparatus which, for that matter, are described almost exclusively from the theoretical viewpoint. Excellent schematic diagrams in satisfying numbers enliven the pages but photographs or other illustrations of instruments and other acoustical products are reduced to what the reviewer believes to be less than the adequate minimum even for a treatise which is not a handbook but a text.

In avoiding the use of confusing terminology, or in clarifying their meaning when forced to use these designations, the authors have done a better job than do some other current writers. The fact is that even today some terms have entirely opposite meanings in electrical and in acoustic practice. A "receiver" in acoustics is a "transmitter" in telephony, and *vice versa*. Here, too, one detects the practical value of previous utilization of the original manuscript as the text of a lecture course.

One will search the book in vain for popular dissertations on "the wonders of sound" such as appear in some scientific and technical magazines. Impelled by curiosity, the reviewer first of all sought information on several subjects of personal interest, and found leads in neither the index nor the table of contents, but finally stumbled across one or two. The reader may be interested in one example, Geological surveying by means of acoustic instruments. It was not expected, of course, that this subject would receive separate treatment and it was not a source of surprise to find that the words "geological," "surveying," "earth" and "seismograph" do not appear in the index. When looking for this last, the eye fell on "seismic waves, velocity of" and there was found a ten line discussion under Transmission of Sound in Solids. Similarly, a specialized interest in microphones would make the casual reader chase all through the book. Again, the most satisfying discussion on the general types of acoustic detectors (possibly the only one in the book) is found in the chapter on "Subaqueous Sound Signalling." Of all places!

This treatise, therefore, is certainly not designed as a quick reference manual. This does not, however, apply to the book as a whole, for the appendices do constitute exactly such a handy reference work, including a wealth of the latest practical data conveniently presented in tables. Nor do we mean to imply that interesting subjects have been seduously avoided. Chapter IX on Physiological Acoustics (i.e., speech and hearing) presents a number of brief discussions not one of which fails to capture attention. This material is abbreviated because that general field is adequately covered in other works (especially Fletcher's) and hence this fifteen page chapter takes the student through a rapid succession of thought stimulating résumés—energy flow of speech, nature of speech sounds, the theories of audition, etc. For example, under Limits of Audibility there appears the "threshold" diagram which was first presented by Fletcher and Wegel in 1925 (and which we remember having seen reproduced in various other works); and under Loudness and Minimum Perceptible Intensity Differences the reader is even taken for a little excursion in the realm of psychology, in that Fechner's Law and MacKenzie's vertificative experiments on its application to hearing, are duly brought in. To the fascinating subject of how we hear, exactly one page is allotted, ending

with the assertion that "a thoroughgoing biophysical and biochemical study of the auditory nerve process is imperative." Which is as certain as the improbability of man's concluding such a study in the next fifty years.

The publishers have well done their part: Typography, paper, presswork and binding are flawless.

Now that the nuptials of Science and Industry are accomplished, with the happily united twain sallying forth arm in arm to the Temple of Orpheus—via acoustic research laboratories and engineering development departments—this book will provide a timely impetus to the new industries which add to our aesthetic gratifications and material comforts that are based on hearing sounds . . . and on not hearing noises!—M. F. Béhar.

GRUNDZÜGE DER ZÄHLERTECHNIK. *Ein Lehr-und Nachschlagebuch von Dr. Ing. W. V. Krukowski.* Julius Springer, Berlin, 1930. Cloth 6¼ x9¼, 521 pages. Price 34 RM.

This volume was prepared at the instigation of the Verband Deutscher Electrotechniker and is meant to serve as treatise and handbook for those who want to submit to the examination as meter-engineers. Although it is assumed that the fundamentals of electro-mechanics are familar to the readers, yet Chap. I deals with the general principles of direct and alternating current of which the latter especially is treated so clearly and yet more simply than is found in a book on this subject alone.

In Chap. II the action and construction of meters in all their different types and for all purposes is covered exhaustively; the numerous illustrations in this chapter show not only German but also foreign types. Particular attention is paid to the connections in three-phase meters and the phase-relations. The chapter concludes with a detailed description of details of design and construction.

Chap. III is devoted to tariff-meters and discusses first the various methods and reasons for these meters, which in Europe are much more in use than here with the exception perhaps of a fixed tariff meter (lump sum) with current limit. Registers and counters in these meters are described in detail. A very instructive paragraph is the one on clocks and clockwork systems. The important question which often harasses our utility companies as to how to deal with power factor in consumers plants is treated in Chap. IV., and instrument transformers for metering purposes are described in Chap. V. Of most practical value is Chap. VI covering calibration of meters. It describes first measuring systems, units, and standard, measuring and calibration methods and then in detail, how a meter must be tested. Chap. VII deals with maintenance, how the delicate parts are to be cleaned and how meters should be installed; further, which points are important for the selection of meters. Greatly welcome will be the paragraph on faulty connections which, as many a station engineer knows, is a frequent annoyance. The reviewer knows of no other book where all possible errors in the connections are so fully described as here. In an appendix definitions, ormulas, physical quantities and the German regulations for the official testing and certifying of meters are given, and standard connection diagrams illustrated. Although written in German, this volume should be on the desk of every meter engineer as it provides a never-failing source of information on any question, be it of a theoretical or especially a practical kind.—Max. Hartenheim.

PHYSIKALISCHE STAUBBESTIMMUNGEN. O. M. Faber. *Second volume of "Messen und Prüfen," Monographs covering the field of measuring and testing.* Published by Wilhelm Knapp, Halle, 1930. 8¼ x 5½ inches, paper 34 pages. Price 3.50—R. M.

The determination of kind and amount of dust present under certain conditions has recently become of predominant importance. While the chemical determination can be made with perfect accuracy, up to the present the physical determination has been rather neglected and, where made, does not supply results immediately comparable. The author has, therefore, tried to put together methods in use and results so far obtained of tests for the determination of the following physical properties of dust: specific gravity, pouring weight (with which the author has reference to the weight per unit volume of dust or a similar mass when poured loosely into a container), humidity, grain size, shape of grain and flying capability.

The usual determination of specific gravity is made by pycnometer but tests reveal a great dependence on what liquid is used; methanol gave the highest, toluol the lowest, water a medium value of these 3 liquids. The determination of dust in gases and solid bodies is also discussed. The testing of the other physical properties is treated much in detail, but after all the author comes to the conclusion that although a scientific method for the determination of dust is possible yet up to now no reliable methods have been developed. Besides, certain conceptions as "floatability" and "stirrability" should first be defined before standard methods are agreed on. The little book can be recommended as a guide for those having to deal with similar problems. A list of 40 bibliographical references is added of which unfortunately only one is English and one is French.—M. Hartenheim.

The Edison Storage Battery Company of Orange, N. J., manufacturers of the Edison Nickel Iron Alkaline Storage Battery announce the production of a storage battery of greater capacity than the present "A" type.

The new battery is known as the "C" type. It has the same characteristics as the well known "A" type—but has a 50% greater capacity. To users of storage batteries for heavy duty service the new Edison "C" type storage battery offers 50% greater available current in the same square dimensions of battery compartment space.

CURRENT LITERATURE REVIEW

Abstracts on instruments and devices for measurement, inspection and control

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PRESSURE

Piezo-Electric Indicator for High-Speed Explosion Motors (Piezoelektrischer Indikator fuer schnellaufende Verbrennungsmotoren). J. Kluge & H. E. Linckh. Zeitschrift Verein deutscher Ingenieure, June 21, 1930, pages 887-889.

After discussing the familiar indicators a new instrument is described which operates by piezoelectric pressure measurement, that is, the forces to be measured act on a quartz crystal and produce on this crystal charges proportional to the forces. The apparatus consists of a pressure measuring chamber of steel in which 2 pieces of quartz are placed, and a tube voltmeter. The chamber is built directly into the cylinder of the motor. The greatest sensitivity of the indicator is 11 mm. deflection for one atmosphere. The range can be increased to 1000 at. by addition of a condenser. The inherent frequency of the oscillograph loop is 2000 Hz, that of the chamber 100000 Hz. A few diagrams taken on a single cylinder four-stroke motor on 8PS are reproduced. From the pressure-time diagram the indicated Horse-power of the motor can be simply determined. 10 references.—H. A.

The "Pi" Meter (Das Pi-meter). Average pressure indicator by Jos. Geiger. Zeitschrift fuer Feinmechanick und Praezision, Aug. 15, 1930, pages 2-5.

This instrument serves to determine the average indicated pressure in reciprocating engines and gives directly, without taking a diagram and planimetering, the average pressure. The instrument is connected in the same way as an indicator, the gas pressure acts on a piston moving a mass of certain inertia which assumes, under the periodic impulses from the piston, an average position which is read directly on the scale. It is said that the instrument can be used even for very high-speed engines.—H. A.

SPEED, ACCELERATION, TIME

Determinging Production Times in Rolling Mills by Means of Recording Meters. (Zeitenmessung an Walzenstrassen durch aufschreibende Stromzaehler). K. Veit. Stahl und Eisen, Aug. 28, 1930, page 1233.

The report of a rolling mill production record is given to illustrate the necessity of obtaining reliable figures on the power consumption for determining the production costs of a rolling mill.—G. N.

Eddy-Current Tachometer with Actual Displacement of the Magnet (Wirbelstromtachometer mit axialer Magnetverschiebung). Erhard Horn. Zeitschrift Verein deutscher Ingenieure 1930 Nov. 16, 1930, pages 515-517.

This is an ordinary eddy-current instrument modified in such way that not the number of revolutions alone are indicated but the product or quotient of the number of revolutions of a shaft and another variable as is required for instance when a cutting velocity (in a lathe) is to be measured, or the amount of paper or similar goods rolling off a reel. Instead of the displacement of the magnet by the instrument itself it can also be displaced by another outside influence which is measured by another instrument.—H. A.

SPECIFIC GRAVITY, DENSITY AND WEIGHING

Theory of Construction of Scales of Lever Scales (Theorie des Skalenaufbaus von Hebelwaagen) J. J. Wassiljew, Zeitschrift fuer Instrumentenkunde, Nov., 1929, pages 557-556.

The author considers the following types of scales: (a) scales which indicate the weight, (b) scales which indicate the number of yarn in textile industry, (c) scales which give the proportion of weight of two bodies, (d) scales which indicate the proportion of weight in per cent of any body to another body. The mathematical derivations are given yielding 19 formulas.—E. F.

Automatic Weigher for Pulverised Fuel. Electrical Review, June 13, 1930, page 1131.

Describes machine developed by W. & T. Avery, Ltd. Birmingham, England, for handling and accurately weighing pulverized fuel. It has a capacity of ½ ton per discharge.—M. S.

PHYSICAL TESTING

Machine Determines Wearing Qualities of Textile Fabrics. Textile World, July 26, 1930, page 55.

Machine for testing wearing qualities of textiles is described, test results are tabulated.—G. N.

Compression of Rubber—Some Experimental Results. F. Jacobs. Rubber Age, Sept. 25, 1930, page 653.

Translated from Le Caoutchouc et la Gutta-Percha, July 15, 1930.—M. F. B.

Testing the Machineability by Means of the Leyen Setter-Pendulum. (Die Pruefung der Zerspanbarkeit mittels des Leyensetter-Pendels). A. Wallichs & K. Krekeler. Archiv fuer Eisenhuettenwesen, July 1930, pages 41-44; Stahl und Eisen, July 31, 1930, page 1096.

The Leyensetter pendulum was constructed to test within a short time the machineability of steels and to replace the expensive and long-time method of taking time-cutting curves. The following tests were made: (1) Testing of the ground cutting took in the double pendulum to determine if the cutting edge is intact. (2) Testing the tool by a certain turning test. (3) Determination of the wear of the tool by this cutting test by means of the secondary pendulum. The best and most uniform results were obtained with a tool of the composition. C: 114%, Cr: .7%, V: .2%, W: 5%. High speed steel cannot be successfully used. The pendulum seems to be fit under conditions also for testing the cutting qualities of cool steels.—G. N.

New German Tensile Testing Machines. (Neue Deutsche Zerreissmaschinen). M. Moser. Stahl und Eisen, July 31, 1930, pages 1086-1088.

The article describes and illustrates some new German tensile testing machines the details of which fulfill the requirements of the Material Testing Committee of the Verien deutscher Eisenhuettenleute. The description covers a 60 ton universal testing machine with hydraulic power generation built by Losenhausen A. G., at Duesseldorf, a 50 ton tensile testing machine with mechanical power generation which is built as a special machine for fine measurement tests by Mohr & Federhaff, Mannheim and finally a 50 ton tensile testing machine for hot tensile tests built by MAN, Nuernberg. This machine has also mechanical power generation.—G. N.

A Simple Abrasion Test Machine for Rubber. P. A. Sigler & W. L. Holt. India Rubber World, Aug. 1930, pages 63-66.

The article describes a simple abrasion test machine for rubber, its construction method of operation, and test conditions. Outline of a rubber abrasion standard. G. N.

The Determination of Elastic Limit and Yield Point of Spring Steel Wire by Means of the Twist Test. (Die Bestimmung der Elastizitaetsgrenze und der Fliessgrenze von Federstahldraehten durch den Verwindungsversuch). E. Siebel & A. Pomp. Mitteilungen Kaiser Wilhelm Institut fuer Eisenforschung, Vol. 12, No. 7, 1930, Report 149, pages 85-91; Stahl und Eisen, Aug. 21, 1930, pages 1206-1207.

In order to obtain reliable results in testing wire by means of the twist test, the authors designed a new apparatus which is able to determine exactly the number of twists for a distinct test length. The new testing method was used to determine the yield curve of patented wires for tension and compression springs. The "twist characteristics," as resulting from the data obtained with the apparatus, give the values of elastic limit and yield point. Since this new method requires too much time for daily routine testing, it is sufficient to determine only that in a certain total twisting the permanent twisting does not surpass a maximum standard value. These standard values have been determined for a group of spring steels.—G. N.

The Testing of Thin Sheets by Means of the Deep-Drawing-Widening Test. (Die Pruefung von Feinblechen durch den Tief-zieh-Weitungsversuch). E. Siebel & A. Pomp. Mitteilungen Kaiser Wilhelm Institut fuer Eisenforschung, Vol. 12, No. 9, 1930, Report 151, pages 115-125; Stahl und Eisen, Aug. 21, 1930, page 1207.

Whereas a former publication on a new deep-draw test (E. Siebel & A. Pomp, Mitteilungen Kaiser Wilhelm Institut fuer Eisenforschung, Vol. 11, (1929) pages 287-291, Report 136; Metals & Alloys, Vol. 1, May 1930, page 524). Referred to the development and the theoretical principles of the new test method, this publication gives the results of actual tests on steel and non-ferrous metal sheets. Tensile tests and microscopic examinations were also carried on for comparison. The results are that the deep-draw-widening test is an excellent means to distinguish the qualities of various sheet brands. This test method gives especially valuable information on the structure of the materials tested. The deep-draw-widening test will determine in many cases, where other test methods fail, the suitability of sheets for deep drawing purposes.—G. N.

Laboratory Flexing Tests as an Aid in Investigating the Pneumatic Tire Carcass. H. A. Depew & H. C. Jones. Preprint 105, American Society for Testing Materials, June 23-27, 1930, 11 pages; Rubber Age, July 10, 1930, pages 369-372.

In an investigation of laboratory methods that may be applied to the development of the pneumatic tire carcass, it has been found that a pulley flexing test using small belts gives information that should be applicable to high-pressure tires. A free bend test gives additional information when very low pressures are used, and a jerking test gives information regarding the quality of the cord. The tests indicate that tire carcass construction should be considered in connection with the compounding of the pneumatic tire carcass.

Service Tests on Rubber Belts. E. G. Kimmich. Preprint 104, American Society for Testing Materials, June 23-27, 1930, 7 pages; Rubber Age, Aug. 10, 1930, pages 479-480.

The paper gives results of extensive tests on rubber belting to determine the relative influence of various service conditions on the time that a belt will resist ply separation. Various combinations of pulley diameters, tensions, belt speeds and thicknesses were used. The test belts were applied on two pulleys to equal size under controlled tension, and run until ply separation took place. The time required to separate the plies is given in a mathematical expression based on these tests. Some representative parts of the original data are given in the form of graphs which also include curves to show the close agreement between data and formula. It was found that the relative ply-separating influence of the factors studied could be determined with equal accuracy with or without transmission of power. Because of the greater simplicity most of the tests were run without power transmission. The tests reveal that the influence of several of the factors upon the service obtainable from a belt is much larger than usually considered. In fact, while the belting manufacturer may improve the belt resistance to ply separation by several times as has been accomplished in recent years, it is shown that the user of the belting has it within his power to increase or decrease the severity of the belt installation by much larger amounts by his selection of pulley sizes, tensions number of plies and belt speeds.

A Note on Fatigue Tests of Nitrided Steel. N. L. Mochel. Preprint 42 American Society for Testing Materials, June 23-27, 1930, 5 pages.

In this note, fatigue test data on chromium-aluminum-molybdenum steel, before and after hardening by the nitriding process, are given. The tests were made on rotating cantilever specimens. Data are also given as to the chemical composition and the tension, impact and hardness characteristics of the material used.

Hardness By Mutual Indentation. I. H. Cowdrey. Preprint 52, American Society for Testing Materials, June 23-27, 1930, 12 pages.

Mutual indentation has long been recognized as a practicable method for determining hardness. Several investigators have made use of it with crossed prisms and cylinders using various functions of the indentation and load as hardness indicators. The author has made use of both crossed and parallel cylinders and has shown that in each case a simple linear function suffices to transform the resultant data to Brinell hardness. This transformation constant appears to be independent of material, size and proportions of the test cylinders, and over a reasonable range independent of the pressure used.

VIBRATION, SOUND, LIGHT, COLOR

Contribution to Measurement and Analysis of Mechanical Vibrations (Beitrag zur Messung und Analyse mechanischer Schwingungen). Heinrich Hoffman. Messtechnik, July 1930, pages 181-186.

An investigation shows that the measurement of mechanical oscillations in only one component is ambiguous and does not give any indication as to how the vibration actually originated. The real character of plane vibrations can be recognized only in the polar diagram. A few illustrations show the most important characteristics of vibrations and a method for taking polar diagrams is described.—Ha.

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Ross' Modification of the Hilger Interferometers for Testing Large Optical Elements. O. G. Hay. Transactions Optical Society, Vol. 31, 1929-30, pages 91-105.

The instrument is a modification of the Hilger lens and prism interferometer and is intended for use in testing and figuring large optical elements such as astronomical telescope objectives, coelostat mirrors, etc., where the free aperture of the test element is larger than the normal aperture of the interferometer.

A detailed description with drawings of the apparatus for testing optical systems of about 12 in. diameter is given and the importance of geometrical design of the various parts is emphasized. It is intended to construct the proposed interferometer for the purpose of ascertaining the possibilities and limitations of the method and then, with the experience derived from this instrument, to apply the method on a more ambitious scale.

Acoustical Properties of Some Sound Collectors for the Aircraft Sound Collector. J. Obata & Y. Yosida. Report Aeronautical Research Institute, Tokyo Imperial University, No. 62, July 1930, pages 231-247.

Acoustical properties of two parabolic reflectors (dia. 2 m., depth 46 and 35 cm.) and two exponential horns (opening dia. 84 and 35 cm., length 300 and 100 cm. respectively) were investigated. The experimental method was entirely of electric, i.e., the directive property and magnifying power for sounds of various wave-lengths were determined by the air of a microphone and amplifier, and for parabolic reflectors the distribution of the sound intensity along the axis was also measured. It is found that the parabolic reflector has excellent directive property, though the magnifying power is not large. On the other hand, single horn was found to be almost nondirective for sounds of lower frequencies, so that whichever method, aural or electrical reception, may be used the time difference or phase difference at two horns should be utilized in order to employ the horn for the aircraft sound locator.

The Analysis of the Colors Observed in Photoelastic Experiments. R. V. Baud & W. D. Wright. Journal Optical Society of America, July 1930, pages 381-395.

In this paper an account of the production of the color fringes in photoelastic experiments is given in detail. In Part I the equation governing the reduction in energy transmission for given wave lengths and retardations is developed. In Part II some influences are discussed which modify the final light distribution but which, either owing to the present lack of experimental data or for some other reason, have been neglected in the calculations. In Part III a detailed color analysis is made of the fringes produced in models with stresses giving retardations up to 2μ.

VIBRATION, SOUND, LIGHT, COLOR

The Universal Light-Meter of Voege (Der Universal-Lichtmesser nach Voege). Paul Kruess. Zeitschrift fuer Feinmechanik und Prazision, Sept. 18, 1930, pages 4-6.

The circular field of vision of this instrument is divided in 2 parts by a zig-zag line, one part is illuminated by the surface the illumination of which is to be measured, the other by a little incandescent lamp. The zig-zag line is made to diappear by regulation of brightness of the lamp or by an iris shutter. Description of arrangement and 2 references are given.—H. A.

Maple Sirup Color Standards. R. T. Balch. Industrial & Engineering Chemistry, March 1930, pages 255-257.

The author has determined the average percentage of caramel which should be used for each color unit, based upon both the spectrophotometer and Pfund grader readings, to give a more uniform increment of color between adjacent color units. Tables and curves are given comparing the Bryan's and the revised specifications for caramel. Two references.—M. E. H.

Photometry of Automobile Head-Lamps (Zur Photometrierung von Automobilscheinwerfern). F. Born. Elektrotechnische Zeitschrift, Aug. 28, 1930, pages 1239-1241.

A method is developed and a measuring arrangement described which permits the evaluation of the results found in the laboratory for the actual distribution of illumination on the road. The method is illustrated by an example.—H. A.

Instruments for Testing and Adjusting Optical Systems. C. H. Morgan. Review of Scientific Instruments, July 1930, pages 404-412.

The following instruments are considered: achromatic lens testing and cementing instrument, ocular prism testing and cementing instrument, focal length comparator and veticle variable power testing instrument.

CHEMICAL ANALYSIS AND APPARATUS

The Micro-Ionometer (Das Mikro-Ionometer). Lautenschlaeger. Zeitschrift fuer Feinmechanik und Praezision, Aug. 31, 1930, pages 4-5.

Portable potentiometer for determining the hydrogen-ion-concentration. The whole apparatus weighs 12 kg.—H. A.

Design of Fractionating Columns—With Particular Reference to Petroleum Distillation. R. B. Chillas & H. M. Weir. Industrial & Engineering Chemistry, March 1930, pages 206-213.

This paper presents a method which was used in the design of a 30-plate column to separate 8000 gallons per hour of crude petroleum into six-commercial fractions. Observations on bubble-plate action using vapor velocities of 2 to 6 feet per second thru the free space of the column, heat balance calculations, and a sectional type of plate which requires neither machine work nor the use of any packing in its assembly are presented, together with some brief notes on some accessory apparatus. The method is applicable also to other distillation problems. 6 references.—M. E. H.

Large Glass Distillation Equipment. D. F. Othmer. Industrial & Engineering Chemistry, April 1930, pages 322-325.

Distillation columns and accessories constructed of glass of a larger size than have previously been used are described. Connections are made with Pyrex flanges and the equipment is substantially all glass, simple and ruggedly designed. 5 references.—M. E. H.

Graphical Rectifying-Column Calculations. Theodore Baker & Jay S. Stockhardt. Industrial & Engineering Chemistry, April 1930, pages 376-377.

A modification of McCabe and Thiele's method is given for the design of fractionating columns. It leads to practically the identical results of Murphree's. The relation between these methods is pointed out and a simple direct means of arriving at Murphree's working equilibrium curve and the necessary number of actual plates is given. 3 references cited.—M. E. H.

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Laboratory Methods of Testing the Volatility of Motor Fuels. E. A. Goode. Chemical Engineering & Mining Review, July 5, 1930, pages 366-368.

Three properties paramount in the evaluation of a motor fuel are: (1) knocking tendency, (2) stability during storage, and (3) volatility. A summary is made of methods for measuring the volatility of fuel and their relative values indicated. While laboratory tests may give some idea as to the relative values of fuels, engine tests are still necessary for accurate evaluation.—W. H. B

The Preservation of Standard Thiosulphate by Means of Amyl Alcohol. F. H. Campbell & F. J. Watson. Chemical Engineering & Mining Review, June 5, 1930, pages 340-342.

An investigation of the changes taking place in standard thiosulphate solutions led to the following conclusions: (1) thiosulphate solutions continue decomposing indefinitely, (2) the decomposition is due to bacteria and not CO_2, (3) if bacterial action is prevented, only negligible alterations in concentration occur over a period of several months, (4) 1% by volume of amyl alcohol is an efficient bastericide under ordinary laboratory conditions, (5) the amyl alcohol does not interfere chemically in the use of the standard thiosulphate solution, but has a definite effect on the physical properties, and (6) amyl alcohol can be used as a preservative for the boiled starch indicator solution.—W. H. B

Acidity in Insulating Oils. G. L. Sumners. Electrical World, Aug. 9, 1930, pages 261-263.

Acidity is now reported, in oils, as the number of millograms of KOH required to neutralize one gram of the oil, and the value is known as the neutralization number. New oil should require no more than .03 mg. of KOH to neutralize one gram of oil. High acidity favors sludge, due to the gradual picking up and combination with oxygen to form peroxides, alcohols, ketones, and acids. A combination centrifuge and blotter press will remove the sludge, but not prevent further sludging. It is but slightly beneficial in reducing the acidity. Remedies for acidity include: neutralization with alkali, the use of Fuller's earth, activated carbon, or silica gel, or the use of a weak alkali such as water glass with centrifuge. Acidity and dielectric strength are shown to be unrelated, and oxygen is indicated to be the chief enemy of oil. It is considered safe to assume that oil requiring 0.2-.3 mg. KOH is sufficiently low to indicate the oil to be in good condition.—W. H. B.

A Simple Apparatus for Electro-Metric Titrations (Eine einfache Apparatur fur elektrometrosche Titrationen). W. Pfluecker & W. Keilholz. Chemikerzeitung, June 11, 1930, pages 451-452.

An apparatus made by E. Schmidt, Reinscheid, is described which permits the determination of very diluted organic solutions with an electric galvanometer.—Ha.

A New Type of Continuous SO_2 Recorder. C. O. Sisler. Abitibi, June 1930, pages 1-2, 33.

Instrument developed by engineers of Abitibi Power & Paper Co., Ltd., is described.

Photo-Electro Metallurgy. Roy W. Drier. Industrial & Engineering Chemistry, Feb. 1930, pages 153-157.

A new method of separating minerals, metals and metallurgical products on the basis of color and luster is described. This method uses a beam of light and a photo-electric cell actuated by the light reflected from the particles of material, and the separation is based on the differences in the reflective indices of the materials. The separator circuit is diagrammed.—M. E. H.

VISCOSITY

A New Consistometer and Its Application to Greases and to Oils at Low Temperature. R. Bulkley & F. Bitner. Bureau of Standards, Journal of Research, July 1930, pages 83-96.

A consistometer is described which is suitable for determining the consistency of viscous and plastic materials in general, but which is more particularly advantageous in obtaining flow-pressure diagrams for materials which change rapidly in consistency with time or which show a breakdown of structure with mechanical working. The limitations of some commonly used instruments are discussed, and the sources of error in the present instrument are pointed out. Flow-pressure graphs of a cup grease at different temperatures and of various plastic oils at 0°C. are shown.

The importance and the significance of the unworked consistency of the undisturbed material and of the thoroughly worked consistency of the completely broken down material are discussed. The method of measuring these properties of the material with the new instrument are described in detail.

Use of the Mobilometer for Measurement of Consistencies of Ceramic Glaze Slips. E. D. Turnbull. Ceramic Age, June 1930, pages 330-331.

The measurement of glaze slip is discussed.

A New Viscosimeter—The Schaffer Drop Viscosimeter (Ueber eien neuen Oelzaehigkeitsmesser) Zeitschrift fuer Feinmechanik und Praezision. Oct. 15, 1929, pages 1-5.

The article describes this new instrument.

PHOTOGRAPHY

A New Ultra-Speed Kinematographic Camera Taking 40,000 Photographs per Second. T. Suhara, N. Sato & S. Kamei. Report No. 60, Aeronautical Research Institute, Tokyo Imperial University, May 1930, pages 187-194.

We have recently devised an extremely high-speed kinematographic camera capable of taking photographs at all speeds up to the rate of 40,000 per second. The normal speed projection, at the rate of 16 pictures per second, of the prints obtained from these original negatives gives them an apparent reduction of 2,500 times in the speed of movement of the object photographed. About 1,000 photographic impressions can be taken on the film of 4 metre long in this machine. Various photographs of the motion of sound waves inside a cylindrical and an elliptic shell taken with this machine are shown.

Photographic Action from Metals, Woods, Etc. G. Strachan. Journal Royal Technical College. Vol. 2, Jan. 1929, pages 20-29.

Experiments are described showing the photographic effect produced in the dark by certain metals, woods and liquids.

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Standardization of Ozone Testing. E. P. W. Kearsley. Rubber Age, Sept. 25, 1930, pages 649-652.

The difficulty encountered heretofore, when attempting to obtain comparable results, has been one of obtaining suitable and consistent concentrations of ozone for the experiments. A method is described which provides favorable conditions for the conducting of such tests, and it is demonstrated that under such conditions constant and comparable values are obtainable. It is further shown, that these results are of value when studying the properties of various compounds, and are especially adopted for the evaluation of ozone resistant compounds. Proposals are made for the avoiding of ozone cracking, and the necessity of intensive research work in this field and the possibility of correlating the results obtained with ozone aging with natural aging is emphasized. —M. F. B.

Testing Equipment for Refractory Material. L. Litinsky. Ceramic Age, Aug. 1930, pages 109-113.

This instalment covers: (5) Bonding Strength, (6) Macrosturcture, Form and Mass, (7) Microscopy, (8) X-Ray Investigation, (9) Porosity, Density, Specific Gravity, (10) Penetrability.—M.F.B.

The Denny-Edgecombe Direct Vision Torsionometer. Instrument World. Sept. 1930, pages 118-119.

Electrical transmission replaced by optical system in new instrument applicable to propeller & other shafts, accurate to 0.0033 degree of arc and adaptable for shafts of different diameters. —M. F. B.

Some Microphone Measurements and Some Suggestions with Regard to Microphone Arrangements. Siffer Lemoine. Electrical Communications, Oct. 1930, pages 139-154.

A veritable treatise:—Deduction of fundamental formula; account of measurements concerning the magnitude of diaphragm effect when the angle of incidence is variable; measurements concerning the magnitude of the diaphragm effect at varying distances; applications of one of the author's formulas; general investigations; conclusions with regard to handling of microphones in broadcasting studio rooms, etc.—M. F. B.

The Holding Time Recorder. R. I. D. Nicoll. Bell Laboratories Record, Aug. 1930, pages 594-597.

The need of holding-time data in planning for future. Disadvantages of human observations. Description of automatic holding-time recorder and of its varied uses. Interesting schematic diagram.—M. F. B.

Microphonic Action in Telephone Transmitters. F. S. Goucher, Bell Laboratories Record, Aug. 1930, pages 566-569.

Construction of apparatus used in the study of physical changes responsible for the variations in resistance that take place when an aggregate of carbon granules is subjected to variations of stress at audible frequencies. Arrangements for controlling the pressure and temperature of the contact between single granules of microphone carbon. Conclusion is that "microphonic action is probably the result of variations of contact area with elastic deformation of the contact meterial." —M. F. B.

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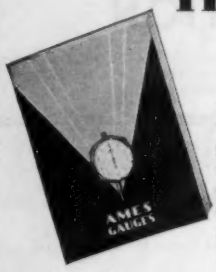

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ADVERTISERS' INDEX

A

Ames Co., B. C., Waltham, Mass. 27
Amthor Testing Instrument Co., 309 Johnson St., Brooklyn, N. Y. 13
Atlas Electric Devices Co., 360 West Superior St., Chicago, Ill. 13
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia, Pa. 13

B

Bausch & Lomb Optical Co., 637 St. Paul St., Rochester, N. Y. 5
Bristol Company, Waterbury, Conn. Back Cover
Brown Instrument Company, 4482 Wayne Ave., Philadelphia, Pa. 3
Buffalo Meter Co., 2926 Main Street, Buffalo, N. Y. 27
Burgess-Parr Co., 111 West Monroe St., Chicago, Ill. 10

E

Esterline-Angus Company, Indianapolis, Ind. 4

F

Federal Products Corp., Providence, R. I. 28

G

Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill. 23
General Radio Company, Cambridge, A., Massachusetts 13
Gordon, Claud S., 708 W. Madison St., Chicago, Ill. 23

L

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. 8

M

Meriam Company, Madison Ave., at W. 112 St., Cleveland, Ohio 26
Minneapolis-Honeywell Regulator Co., 2735 Fourth Ave., So. Minneapolis, Minn. 7

R

Rawson Electrical Instrument Co., 90-92 Windsor St., Cambridge, Mass. 6
Rubicon Company, 29 North Sixth St., Philadelphia, Pa. 28

S

Suter, Alfred, 200 Fifth Avenue, New York 1

T

Tagliabue Mfg. Co., C. J., Park and Nostrand Aves., Brooklyn, N. Y. Inside Front Cover
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ARTHUR SCHRODER, INSTRUMENTS, Vol. 4, No. 1, January 1931, pages 3-16, 15 figs.

The first installment of this book covers the introduction and part of Chapter I. Chapter I will cover Balances, Scales and Weights.

HANDBOOK OF INDUSTRIAL INSTRUMENTS.

M. F. BÉHAR, INSTRUMENTS, Vol. 4, No. 1, January 1931, pages 17-26, 8 figs.

Chapter XI. Pressure Measuring Instruments. This installment is devoted to plant standards.

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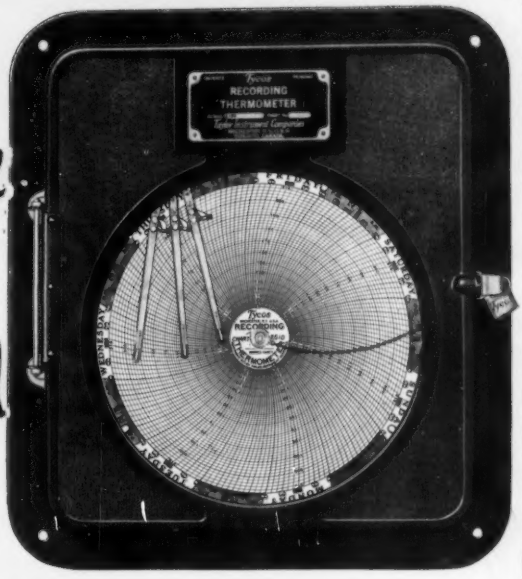

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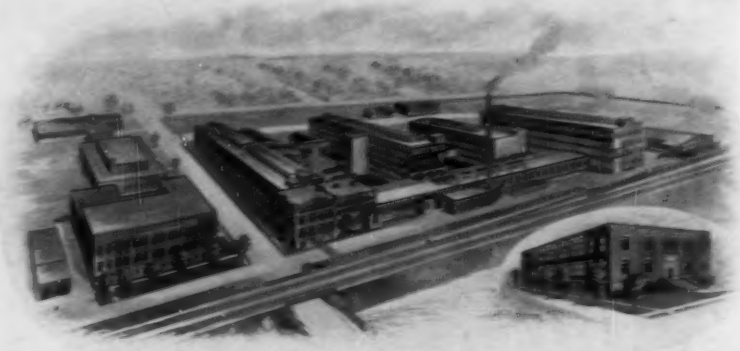

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